DOCUMENT RESUME

ED 058 389 VT 013 338

AUTHOR	Impellitteri, Joseph T.; Finch, Curtis R.
TITLE	Review and Synthesis of Research on Individualizing Instruction in Vocational and Technical Education.
INSTITUTION	Ohio State Univ., Columbus. Center for Vocational and Technical Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
REPORT NO	Inf-Ser-43
PUB DATE	Jul 71
NOTE	90p.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock No. 1780-0798, $.50)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Computer Assisted Instruction; Computer Oriented Programs; *Educational Development; Educational Improvement; Educational Objectives; Educational Research; Educational Strategies; Educational Technology; *Individualized Instruction; Instructional Design; Programed Instruction; *Research Reviews (Publications); Simulation; Student Characteristics; *Technical Education; *Vocational Education

ABSTRACT

An integrated framework for individualized instruction in vocational and technical education could consist of five components, including the student, teacher, environment, instructional content, and mediation. In this review, research and development materials identified through a computer search of materials in the Educational Resources Information Center (ERIC), are grouped according to this framework. Sections are: (1) Issues in the Design of Individualized Instruction, emphasizing the teacher component, (2) Student Characteristics Research, emphasizing the student component, (3) Educational Technology, emphasizing the mediation component, (4) Instructional Strategies, emphasizing the teacher component, and (5) Instructional Systems Approaches, emphasizing research which takes a more integrated approach to individualized instruction. Studies relating to the instructional component are located throughout the sections. It was recommended that cooperative efforts of practitioners and researchers, including doctoral students, are needed to improve the current status of individualized instruction. We must also acknowledge and utilize selected ideas and devices initially developed for military use. (SB)

Information
Series No. 43

VT 013 338

ED058389

review and synthesis

of research on

INDIVIDUALIZING INSTRUCTION IN VOCATIONAL AND TECHNICAL EDUCATION

ERIC

Clearinghouse on Vocational
and Technical Education

VT013 338

MISSION OF THE CENTER

The Center for Vocational and Technical Education, an independent unit on The Ohio State University campus, operates under a grant from the National Center for Educational Research and Development, U.S. Office of Education. It serves a catalytic role in establishing consortia to focus on relevant problems in vocational and technical education. The Center is comprehensive in its commitment and responsibility, multidisciplinary in its approach and interinstitutional in its program.

The Center's mission is to strengthen the capacity of state educational systems to provide effective occupational education programs consistent with individual needs and manpower requirements by:

- Conducting research and development to fill voids in existing knowledge and to develop methods for applying knowledge.
- Programmatic focus on state leadership development, vocational teacher education, curriculum, vocational choice and adjustment.
- Stimulating and strengthening the capacity of other agencies and institutions to create durable solutions to significant problems.
- Providing a national information storage, retrieval and dissemination system for vocational and technical education through the affiliated ERIC Clearinghouse.

ED058389

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY

Information Series No. 43
VT 013 338

REVIEW AND SYNTHESIS OF RESEARCH ON INDIVIDUALIZING INSTRUCTION IN VOCATIONAL AND TECHNICAL EDUCATION

Joseph T. Impellitteri

Associate Professor and Chairman
Graduate Studies and Research
Department of Vocational Education
The Pennsylvania State University
University Park, Pennsylvania

Curtis R. Finch

Assistant Professor
Department of Vocational Education
The Pennsylvania State University
University Park, Pennsylvania

ERIC Clearinghouse on Vocational and Technical Education
The Center for Vocational and Technical Education
The Ohio State University
1900 Kenny Road Columbus, Ohio 43210

December, 1971

The material in this publication was prepared pursuant to a contract with the Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official Office of Education position or policy.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 50 cents

Stock Number 1780-0798

PREFACE

This *Review and Synthesis of Research on Individualizing Instruction in Vocational and Technical Education* is one of a series of "state of the art" papers in vocational and technical education and related fields. Vocational educators have always been concerned with providing the optimum educational opportunity to each individual. Much research also has been concerned with this important priority topic. This publication should assist in identifying substantive problems and methodological approaches for researchers and curriculum development specialists as well as providing practitioners with a summary of research findings that have application to educational programs.

This review is intended to be an authoritative analysis of the literature in the field. Those who wish to examine the primary sources of information should utilize the bibliography. Where ERIC document numbers and ERIC Document Reproduction Service (EDRS) prices are cited, the documents are available in microfiche and hard copy forms.

The profession is indebted to Joseph Impellitteri and Curtis Finch for their scholarship in the preparation of this report. Recognition is also due David Pucel, University of Minnesota; J. William Ullery, Technical Education Research Center, Cambridge, Massachusetts; and Frank Pratzner, research and development specialist at The Center, for their critical review of the manuscript prior to its final revision and publication. J. David McCracken, information specialist at The Center, coordinated the publication's development.

Members of the profession are invited to suggest specific topics or problems for future reviews.

Robert E. Taylor
Director
ERIC Clearinghouse on
Vocational and Technical Education
The Center for Vocational and
Technical Education

INTRODUCTION

This particular review and synthesis document may be of more interest to some readers than to others. Not everyone will agree with the approach which has drawn material from many areas which are not specifically within the field of vocational and technical education. This particular characteristic, however, may make the publication even more meaningful to a larger audience. By identifying reports which deal with individualized instruction from a broad conceptual base, it will help vocational educators to examine their research activities in light of the work conducted in other settings.

In the reporting of individualized instruction research and development activities priority was placed upon investigations which dealt with instructional problems within the general parameters of vocational and technical education. Other studies were discussed outside those parameters when it was perceived to be necessary for a more adequate coverage of the topic under discussion. Individualized instruction efforts in areas highly related to vocational and technical education (military training, industrial training and other areas of education) were thus included. No attempt was made, however, to prepare a thorough review of research in those related areas.

The materials used in this Review and Synthesis were gathered from several places. A number of useful reports were identified through the computer search conducted by the Educational Resources Information Center (ERIC) Clearinghouse at Ohio State University. As a result of contacting state Research Coordination Unit directors, several other meaningful items were obtained. *Dissertation Abstracts* served as a prime source for relevant doctoral theses. Contacts with key personnel in military training research resulted in the inclusion of many meaningful research efforts from this sector.

Appreciation is expressed to all those persons who contributed materials for inclusion in this review. Space limitations do not allow each person to be listed by name. Specific thanks must be extended to Richard and Cheryl Gumaelius. Their assistance in locating materials for this document is appreciatively acknowledged.

Joseph T. Impellitteri
Curtis R. Finch

CONTENTS

	Page
OVERVIEW	3
Historical Perspective	3
The Concept of Instruction	5
Conceptions of Individualized Instruction	7
Toward an Integrated View of Individualized Instruction	9
ISSUES IN THE DESIGN OF INDIVIDUALIZED INSTRUCTION	11
Instructional Objectives	11
Measurement of Instructional Objectives	13
Evaluation of Individualized Instruction	16
Summary	22
STUDENT CHARACTERISTICS RESEARCH	23
Student Abilities	23
Student Background Characteristics	26
Student Affective Characteristics	28
Summary	29
EDUCATIONAL TECHNOLOGY	31
Programmed Instruction	31
Computer-Assisted Instruction in Vocational and Technical Education	38
Computer-Assisted Guidance and Counseling	42
Simulation	45
Other Media Research	48
INSTRUCTIONAL STRATEGIES	53
Pacing	53
Studies Examining Other Learning Variables	54
Summary	57
INSTRUCTIONAL SYSTEMS APPROACHES	59
Learner-Centered Instruction	61
Computer-Managed Instruction (CMI)	61
Other Instructional Systems Applications	64
Summary of Instructional Systems Development	64
SUMMARY AND RECOMMENDATIONS	67
Synthesis of Individualized Instruction Research	67
Recommendations for Research and Development	69
BIBLIOGRAPHY	71

REVIEW AND SYNTHESIS OF RESEARCH ON INDIVIDUALIZING INSTRUCTION IN VOCATIONAL AND TECHNICAL EDUCATION

OVERVIEW

Historical Perspective

One might say that individualized instruction had its beginnings in the minds of early philosophers. For example, the Greeks had some idea of the consideration which should be given to an individual in the educational process. Plato envisioned society as a place where people would learn well that which they were fitted for by nature (Nash and others, 1965). Aristotle, who was a pupil of Plato, carried the concept of the individual even further. He desired an educational system that would allow an individual, in association with other persons, to guide all his conduct by reason (Wilds and Lottich, 1961). Many other well known persons contributed to the idea of individualistic education. Jean Jacques Rousseau presented his case with the publication of *Emile*. Not only did Rousseau specify in his book that experience is the best teacher, he also indicated that the nature of the youngster is the center of educational inquiry (Bennett, 1926). Similar views were expressed by Friedrich Froebel who advanced a unique educational theory during the early 1800's. Froebel emphasized the individuality of children, and felt it important to recognize their dynamic qualities and to integrate these qualities into the educational process.

The aforementioned teacher-philosophers relate to a common theme, that is, providing consideration to the needs of the individual within the instructional process. It is, however, important to recognize that current conceptions of individualized instruction may take on a somewhat different structure, particularly from the standpoint of comprehensiveness.

What factors then seem to contribute to the current view of individualized instruction? Gibbons (1970) in discussing the origins, the nature, and the contemporary status of individualized instruction, does a thorough job of identifying these factors and classifying them in a meaningful context and the reader is urged to examine this recent article. The attempt to encapsulate briefly herein the major points brought out in Gibbons' article cannot do justice to the magnitude of his effort.

He lists nine types of individualized instructional approaches which have emerged during some point in the history of American education, and concludes that, "individualized programs have been part of American formal schooling almost from its inception, and the revived interest in

individualization has taken a bewildering array of forms." The approaches to which he refers are:

1. Tutoring.
2. Correspondence courses.
3. Self-paced unit plans—the Pueblo Plan, the Dalton Plan, the Winnetka Plan, Individually Prescribed Instruction (IPI), the Nova High School independent study program and Project Plan (Program for Learning in Accordance with Needs).
4. Programmed and computerized instruction.
5. Independent study programs—the Trump Plan and the Montessori Method.
6. Grouping for individualization.
7. Administrative plans.
8. Personal programs—Neill, Erickson, Friedenberg, Goodman, and Holt.
9. Remediation and teaching exceptional children.

It appears that several movements and programmatic efforts have had an effect on individualized instruction as it is perceived today. Among them are the progressive education movement, the work of Skinner and others with emphasis in the area of programmed instruction, the increased thrusts in the area of educational technology, and concern with the identification of objectives in behavioral terms.

Although one might not be able to pinpoint exactly how the progressive education movement evolved, it appears that the influence of early educators and philosophers such as Rousseau and Froebel had a great deal of impact. Likewise, the efforts put forth by Francis Parker and John Dewey cannot be discounted. Their contributions to the foundation of the progressive education movement are indeeed impressive. Perhaps more important than the identification of persons who contributed to this movement is the identification of what aspects of progressive education are relevant to individualized instruction. Although there are different schools of thought, a key precept is that individual differences among children must be recognized (Atkinson and Maleska, 1962). It might be said that this idea had at least as much impact on educational change as any other specified in the progressive education concept.

One outgrowth of this concept was the Winnetka Plan, of significant consequence to future individualized instruction efforts. As Lindvall and Cox (1969) point out:

> The Winnetka Plan for individualizing instruction represents a landmark in the history of the development of individualized programs which has served as a point of departure, or at least of comparison and contrast, for many subsequent activities in this area. . . . In brief, the Winnetka Plan was a procedure for the individualization of instruction involving carefully specified sequences of instructional objectives, tests to determine pupil mastery of these objectives, instructional materials for use in achieving each objective, a procedure for developing individual

lesson plans, and a procedure for monitoring pupil progression through the curriculum.

Another important effort in the attempt to recognize individual differences in school programs was a movement which emerged during the 1920's to develop something called educational engineering (Finn, 1968).

> The leader of this movement was W. W. Charters. . . . Charters' ideas were attacked and pretty well demolished during the thirties by both the social reform and the child-centered philosophers of education. From the middle fifties onward, the Charters' concepts were revived, although in a new form, and were seldom attributed to him.

The concept revived in the fifties to which Finn refers is the "systems approach," currently a strong force in the design of instruction.

Another thrust which seemed to provide a more comprehensive base for the current idea of individualized instruction was the work conducted by B. F. Skinner and his associates. Skinner's extensive research with teaching machines, programmed learning, and the application of reinforcement principles to education have undoubtedly affected the characteristics of individualistic education. His work and the work of others reflected a shift of emphasis from lock-step education to instruction tailored to meet the needs of individual students. More consideration was given to the differences among students with regard to such variables as time necessary to complete instruction and prior knowledge. Additionally, more emphasis was placed on reaching a certain specified criterion rather than identifying where a person might fit along an artificial continuum.

Concurrent with the work of Skinner, a great deal of emphasis was being placed on educational technology as it fitted within the school structure. With the advent of computers and other sophisticated learning devices, a reevaluation was made of the actual role of the teacher within the instructional environment.

Lastly, concurrent with the movement toward increased use of educational technology in the teaching-learning process, a strong effort was made to identify objectives in behavioral terms. The increased emphasis in this area can be, at least in part, attributed to the publication developed by Mager (1962). In this document, he outlines several characteristics of behavioral objectives which, with minor variations, have remained unchanged in texts which have been produced since that time.

These movements or efforts then, have been generally associated with the trend toward a more comprehensive description of individualized instruction. It is this broad-based definition which this document will use as a framework for the topical headings that are provided.

The Concept of Instruction

In order to identify a truly comprehensive concept of individualized instruction, it is first necessary to review the concept of instruction and identify the work which has been done to specify elements which underlie it. Although a general description of instruction may consist of imparting specific knowledges, skills, and attitudes to others, for the purposes of

this document some of the more comprehensive definitions should be examined. It is, therefore, in order to review several of the more recent theories and models which have been designed to interrelate the elements that constitute instruction. MacDonald and Leeper (1965) discuss a model which incorporates an instructional system and a curriculum system. They distinguish between curriculum and instruction as two separate action contexts, with curriculums producing plans for further action and instruction putting plans into action. They feel that curriculum and instruction interrelate with teaching and learning to varying degrees and, therefore, must be taken into account in an educational design. The space within which curriculum, instruction, teaching, and learning overlap constitutes a point of congruence where curriculum goals are operating in instructional settings through effective teaching activities, as evidenced by changing behavior or student learning. "Instruction is differentiated from teaching in that instruction encompasses more of the situational elements. Teaching refers primarily to the human interaction between teacher and pupil" (Association for Supervision and Curriculum Development, 1968).

Theorems for a theory of instruction are proposed by Bruner (1966). The author takes a somewhat scientific approach in setting forth some basic propositions about instruction. He indicates that a theory of instruction should specify the optimal experiences that predispose a learner to learn—it should relate to the structuring of knowledge that is optimal for comprehension; it should specify optimal sequences of presentations of materials to be learned; and finally, it should specify the nature and pacing of reward and punishments in the process of learning and teaching.

An instructional-learning system described by Bishop (1971) analyzes instruction from a more operational standpoint. Within this particular system there are included four basic modes of instruction for all students: large group discussion, small group discussion, individual or independent study, and laboratory instruction. It is further indicated in his model that some learning experiences will be common to all students while others will be unique or individualized for specific students. Additionally, some experiences and learnings will be provided in more depth in certain curricular areas for certain students, and instructional experiences will require variability throughout the school day, week, or year. The author contends that the learning experience is founded upon a concept-oriented or concept-centered curriculum which offers achievement opportunity for all students, regardless of ability or academic potential, and that the learning experience is a plan of continuous progress for all students. An even more pragmatic approach has been devised by Briggs (1970). He provides a model for the design of instruction which consists of 10 steps that are linked together with appropriate feedback lines. These steps, the first of which is stating objectives and performance standards, are supported by detailed descriptions in various sections of the text.

The unique characteristic of the "Instructional Gestalt Paradigm" presented by Siegel and Siegel (1967) is the inclusion of specific independent variables. The four major classes or clusters of independent variables

which are included in the conceptual scheme are those related to learning environments, instructors, learners, and courses. In addition to specifying certain critical variables within each cluster, the authors emphasize the importance of interactions among the various independent variables. They state that these interactions may occur both among the variables within a given cluster and among the variables across the four clusters.

Given the various theoretical and practical frameworks designed to describe the concept of instruction, it may be useful to distinguish between instructional theories and instructional models. An instructional model is merely a convenient way of breaking down the instructional process to identify instructional problems, whereas an instructional theory must reflect some degree of empirical proof, and provide a means for predicting instructional outcomes (Association for Supervision and Curriculum Development, 1968). An instructional theory permits the prediction of learning outcomes, given particular conditions in the educational environment.

Conceptions of Individualized Instruction

What then constitutes individualized instruction? DeHaan and Doll (1964) make several suggestions regarding this question. First, they indicate that emphasis should be placed on the student as a person, on the teacher as a person, and on the interaction that takes place between them. Additionally, they state that individualization occurs when the teacher recognizes and responds to the emotional reactions of the learner as well as to his achievements, mistakes, and deficiencies. The teacher should go beyond ordinary achievement, thereby allowing the student to become more motivated and more confident in his own competency. DeHaan and Doll go on to indicate that the teacher should consider the pupil as in individual with unique perceptions, values, and needs; sensitivity to others' needs is an important aspect of the individualization process.

Edling (n.d.) contrasts individualized instruction with traditional instruction on the basis that the former is oriented toward the child.

> Appropriate learning experiences are assigned to each student. In order to determine what is appropriate for each learner some type of diagnostic procedure is used. Once these learning experiences are identified, instruction is mainly self-directed, self-administered, and scheduled, within the school's broad time constraints, at a time convenient to the learner.

He proposes four types of individualized instruction within this context. These types are:

1. Individually diagnosed and prescribed instruction—the school determines appropriate objectives for the student and also prescribes appropriate instructional strategies for the student's mastering those objectives—may be compared to Gibbons' (1970) previously mentioned self-paced unit plans.
2. Personalized instruction—the student selects appropriate objectives, and the school prescribes instructional strategies for the student's mastery of those objectives.

3. Self-directed instruction—the school determines appropriate objectives for the student, and the student selects the instructional strategy to be utilized in his mastering those objectives.
4. Independent study—the student selects appropriate instructional objectives and selects the strategy to be followed in his mastery of those objectives.

Robert Mager in the introduction to a book written by Thorwald Esbensen (1968) states that an instructional system is individualized when each student's characteristics play a major part in the selection of objectives, materials, procedures, and time. He further comments that it is individualized instruction when the decisions about objectives and how to achieve them are based upon the individual student. A series of questions are posed which can be asked of any instructional system to determine the extent to which it meets the needs of the individual student. Mager concludes by stating that one determines the degree of individualization by asking which instructional decisions have been made and by whom they were made. Individualization of instruction in this context may occur through the variation of objectives from student to student, of rates of progress, of instructional purposes, and of instructional organization (Wilhelms, 1962).

Individualizing instruction for the disadvantaged is discussed in detail by Warner (1970), who states that several variables and the interrelationships between them should be explored when an individualized program of instruction is being developed and implemented. These variables include the students, their characteristics and needs; the teaching staff, their personalities and expertise; the administration, its leadership and support; the community, its involvement and support; and the physical resources (facilities, hardware, and software), their usefulness or obsolescense.

A rather sophisticated approach to the identification of what constitutes individualized instruction has been developed by Gibbons (1970). The author first specifies that the term individualized instruction may refer to a great variety of instructional programs and, therefore, may have little meaning as such. He then develops a classification and a profiling system so that differentiation may be made among certain of the individualized instruction programs. The profiles of several programs were compared and found to be quite different in the degree and kind of individualization they included. Gibbons identified several factors which appear to complicate the concept of individualized instruction, which are:

1. The term individualized instruction is used to describe both minute changes in conventional teaching and changes involving the complete reconstruction of schooling.
2. The term is inherently ambiguous in suggesting separate education for each student or any degree of modification of mass instruction.

3. Each program is individualized by the perception and the response of the individual; or, no program can do more than shape the conditions of learning.
4. Describing the nature of individualization from different points of view leads to different conclusions.
5. Individualized programs vary in the elements of instruction they individualize and the degree of individualization in these elements.
6. The theoretical or philosophical reasons offered for change are seldom fully realized in the proposal that results; rather they are explained or justified as improvements to traditional practice.
7. The individualized instruction program may be offered to only a portion of the school body for a portion of school time.

Toward an Integrated View of Individualized Instruction

There is a great deal of confusion about the definition of individualized instruction. Consequently, the authors of this report felt it necessary to provide a description of individualized instruction within the framework of this document so that a review and synthesis would be more meaningful to the reader. Based upon the previously described models and paradigms, there appear to be at least five basic components within the total framework of individualized instruction. These components could consist of the student, the teacher, the environment, the instructional content, and mediation.

Of these five components, the student seems to be central, with the others being arranged in some manner which is designed to maximize learning. Different arrangements might (and probably would) be more appropriate for reaching different instructional objectives or for two students to reach the same objective. For example, teacher behavior (the teacher component) might be most critical in terms of aiding one student to attain a particular criterion, whereas, another student might be aided to a greater extent by the physical setting (the environment component).

A second point relative to an integrated view of individualized instruction is in order. It seems that these components cannot be examined individually as effectively as they may be investigated in relation with other components. For example, if we were to study the effects of varying instructional mediation on student learning, the inclusion of variables from the student component (i.e. motivation toward learning, ability, prior achievement) might reveal more information about how students having certain personal characteristics interact with certain variations in instructional content.

The sections which follow attempt to group research into somewhat the same framework that has been discussed. Given that a great deal of overlap exists among the various components of individualized instruction, studies have been grouped in accordance with impact they appear to have on specific components. In some cases, where a study has a great deal of overlap among components it is discussed with regard to each component. The teacher component is represented by those sections dealing with the

design of individualized instruction and instructional strategies. Research dealing with mediation is presented in the section titled educational technology. The student is examined in that section labeled student characteristics. Although it was initially felt that the instructional environment component would constitute a separate section, the paucity of research in this area precluded development of such a section. Likewise, a section dealing with instructional content was deemed inappropriate.

It was felt that content is critical to the extent that other components of individualized instruction are examined in conjunction with it. Therefore, studies related to this general area can be found throughout this document. In order to account for research which takes a more integrated approach to individualized instruction, a section dealing with instructional systems is included. This section brings together those efforts which attempt to account for various components of individualized instruction in a systematic manner.

ISSUES IN THE DESIGN OF INDIVIDUALIZED INSTRUCTION

Instructional Objectives

Popham (1969), in tracing the evolution of the current swelling of interest and activity in the area of formulating instructional objectives, points to several factors influencing this trend. He cites the possible impact of such forces as: 1) the programmed instruction movement, 2) increased federal spending on education, 3) the delayed impact of the *Taxonomy* volume of Bloom (1956), 4) the eventual influence of Ralph W. Tyler's writings as well as those of his students, 5) the appearance of such instructional aids as Mager's volume on how to write objectives (1962), and 6) more oblique factors. Other influences which may have had an effect on the emerging popularity of instructional objectives are the more contemporary writings of Briggs (1970), Glaser (1968), Smith (1966), and Stolurow (1965).

Popham's position is that the only sensible reason for the educator's engaging in instruction is to modify the learner's behavior; therefore, these intended changes must be described in terms of measurable learner behaviors. In these terms, an instructional objective must have reference to either an observable behavior of the learner or a product resulting from the learner's behavior. Those writers cited previously, who have in some way influenced the current interest in the formulation of "behavioral objectives," would generally agree with this conception, although each might choose to extend Popham's notion slightly. For instance, Mager (1962) would urge that the conditions under which the behavior occurs and the desired minimal level of learner proficiency be described in addition to the specification of learner behavior.

The necessity for behaviorally specifying instructional goals is intrinsic in the design of each of the many educational system approaches one sees in evidence today. In a later section, the authors examine the nature of "instructional systems" and describe several major efforts utilizing this approach. Suffice it to say that systems designers generally support Popham's view of objectives in the instructional process. Military and industrial training specialists also generally support this view (Koosis, 1970; Straubel, 1971; and Warren, 1971).

With such an extent of agreement among so large and influential a group, why are teachers today not eagerly specifying behavior objectives for use in the courses they are teaching? One criticism raised in opposition to the behavioralizing of instructional objectives is that the easiest learner behaviors to specify and measure are the most trivial and will be overemphasized as compared with the truly important outcomes of education (Popham, 1969).

Eisner (1969) proposes an alternative conception which may serve to overcome that particular objection. He differentiates between two types of educational objectives: instructional objectives and expressive objectives. The former takes on a meaning substantially similar to the behaviorally specified objectives of Popham. The latter "describes an educational

encounter: it identifies a situation in which children are to work, a problem with which they are to cope, a task in which they are to engage." The intent of the expressive objective is to serve as a vehicle through which the skills and understandings acquired earlier can be expanded, elaborated, and personalized for the individual. They are meant to represent the higher level intellectual modes towards which instruction should be primarily directed.

A contrasting approach to the triviality problem posed previously is introduced by Cohen (1967). Like Eisner, he accepts the notion of clearly specified performance objectives. However, he superimposes, a generalized set of goals at the course level toward which the behavior objectives are directed. The obvious intent is to unify a set of specific behaviors into a more generalizable notion, in a hierarchial manner. A further refinement of Cohen's notion is found in a recent article describing a process of occupational curriculum development (Pautler, 1970). In this scheme, Cohen's bi-level structure at the course level is extended to a four-level hierarchy where departmental goals and overall educational goals represent the upper two levels. Canfield (1968) also supports the hierarchical notion but recommends the addition of a rationale or justification for each course goal.

A second criticism of specifying behavioral objectives is that they are far more difficult to generate than those objectives which most teachers use now (Popham, 1969). As is pointed out by one able critic:

> If one tried to state all of the objectives explicitly in advance, he would easily spend all of his time writing objectives and have none left for actually teaching. This may explain why few teachers are actually as foolishly dependent on stated objectives as educational theorists have urged them to be (Ebel, 1967).

An interesting article raising this same issue, and exploring its implications for industrial education has been written by Janeczko (1970).

One approach in dealing with this issue is to eliminate the formulation of objectives as part of the instructional process. It has been proposed that a better way to start would be to design an evaluation instrument which would serve as the statement of outcomes to be met (Evans, 1968). In this case, the ever present question regarding the validity of the behaviors specified would certainly be eliminated. It may be, however, that a confounding of measurement validity would result.

Another aspect to this second issue as raised by Popham is a very practical one. In adhering to vague statements of objectives, it is possible even for large groups of instructors responsible for teaching selected courses to reach agreement. When specified behaviors are attempted, however, such agreement may not be attained easily. Koontz (1970c), in a large scale systems development project at the Naval Academy, recommends that a content map be prepared prior to writing objectives. This map consists of blocks containing an abstract of key words referring to the intended objective, arranged so as to show the presumed learning hierarchy for the objectives.

As applied to vocational and technical education, an additional issue regarding the formulation of performance objectives has been raised. It is proposed that both the educational validity (the extent to which the objective fits meaningfully into the school environment) and the occupational validity (the extent to which the objective specifies a competency essential to the particular occupation for which a student is being prepared) of an objective be examined, and an acceptable standard be met in both spheres (Finch and Impellitteri, 1970). The complexity of the objectives formulation task increases substantially as a result.

Baldwin (1971) discusses behavioral objectives and their applicability to industrial education. He presents a table of general specifications for objectives in industrial education, including specific mention of selected cognitive, perceptual, psychomotor and affective objectives. Two additional tables of specifications for objectives, the first of a course in chassis, suspension, and braking systems and the second for a course in the application of vacuum tubes and transistors, are included in his discussion.

In describing a three-component system designed to evaluate occupational education programs, Conroy and Cohen (1970) emphasize behavior objective development as an essential feature. They state, "Developmental activities with behavioral objectives are essential and constitute an important aspect of the project."

Taking the aforementioned notions of instructional objectives into consideration, it appears that several conclusions may be drawn. First, we are moving at a relatively rapid pace toward the systematizing of instruction with its accompanying reliance upon the behavioralizing of objectives. Second, in moving from where education was in the early 1950's regarding the systematizing of instruction toward where it may be in the 1990's, several compromise steps have been, and will need to be taken. The necessity of these compromise notions stems from the practical impossibility of developing teachers who can adapt to the substantial modification in the teacher's role at the two poles—information-giving versus directing, guiding and stimulating learning. In this changing condition, the focus of instruction which rested primarily upon the teacher in the past is shifting to the learner. Third, the place of instructional objectives at present is in the middle of that shift, necessitating in most educational situations the adoption of conceptions such as those proposed by Eisner (1969) and Cohen (1967). Practically speaking, what those particular notions allow is for the introduction of behavioral objectives into the instructional setting without abandoning entirely the more comfortable notions with which educators have been dealing for years. The authors emphasize that in adopting such intermediary notions, the ultimate intent is to work toward the complete systematization of the instructional process.

Measurement of Instructional Objectives

Given a set of instructional objectives for a vocational or technical course of study, whether behaviorally framed or not, an immediate consideration is the method of measurement to be utilized in assessing the

degree to which these objectives have been achieved (Briggs, 1970; Koontz, 1970c; and Mager, 1967). The purpose of this measurement is to monitor student progress, not to evaluate the overall effectiveness of the instruction. Although certain inferences may be drawn regarding the latter from the results of the former, evaluation of instruction is of a broader concern and is discussed in a separate section of this review. The monitoring function is based upon information describing individual students' progress. Instructional evaluation, on the other hand, involves a judgment regarding the success of a given instructional segment in providing certain desired outcomes for a selected group of students.

As has been pointed out previously (Finch and Impellitteri, 1970), instructional objectives in vocational and technical education must have occupational referents in addition to educational ones. The essential feature of instruction in this area typically provides for objectives in the form of performance or level of competency statements. These performances may be of two general types: task end-product work performances, or task procedure work performances. Recalling Popham's (1969) description of behavioral objectives in terms of either an observable behavior or a product of that behavior, a considerable degree of congruence between these notions is apparent. Extending the notion of these twofold work performance objectives to their measurement, one finds an interesting contrast. Although the techniques for measuring procedural performance differ markedly from techniques for measuring product performance, both are dependent upon the comparison of an individual's actual performance with some criterion performance. What constitutes mastery of a procedural objective is determined in the same manner as the mastery of a product objective—that it meets or exceeds some minimal performance standard.

> In the vocational shop or laboratory setting the emphasis of measurement is upon whether a particular student has or has not achieved a specific objective or set of objectives. Is the student able to perform a specified task within accepted performance standards, or not? (Finch and Impellitteri, 1970)

The measurement task in this setting is what is referred to as criterion-referenced measurement (Glaser and Cox, 1968; Jackson, 1970; Millman, 1970; and Popham and Husek, 1969). The distinction between criterion-referenced measures and norm-referenced measures was initially introduced by Glaser (1963). Norm-referenced measures are those which are used to ascertain an individual's performance in relationship to the performance of other individuals on the same measurement device, while criterion-referenced measures are those which are used to acertain an individual's status with respect to some performance standard (Popham and Husek, 1969). The term "criterion" may mislead one to equate it with end-of-course behavior, a type of overall performance. This is not the case since criterion levels can be established at any point in instruction where it is necessary to obtain information as to the adequacy of an individual's performance (Glaser and Cox, 1968).

Since one cannot distinguish between norm-referenced and criterion-referenced tests by looking at them (Popham and Husek, 1969), what essential difference is there between them? The principal distinction may be drawn in terms of their diverse intents. Whereas criterion-referenced tests are constructed to maximize discriminations made between groups treated differently and to minimize differences between the individuals in any one group, norm-referenced tests are constructed to maximize the discriminations made among people having specified backgrounds and experience (Glaser, 1963).

The implications for instruction of this distinction are quite revealing. The outcome in utilizing a norm-referenced test to assess instructional effect is to identify which of a given number of students "succeed" given a particular instructional process. Criterion-referenced tests, on the other hand, reveal which of a given number of instructional processes "succeed" with a particular kind of student (Moxley, n.d.). Considering the differential effect upon students in the two situations: 1) in the normative situation some students must be successful and others failures; 2) in the criterion-referenced condition students are eventually successful, some utilizing one instructional process, others utilizing another process; 3) in the normative frame student-ranking information may be obtained for the purposes of selection, but not in the criterion-referenced situation.

Given these differing effects upon students, it is the opinion of many persons that the criterion-referenced measurement approach holds a decided advantage for use in vocational and technical education. Reviewing the intent of this approach, individualized instruction is founded on the maximum discrimination between groups administered different treatments (Glaser and Cox, 1968). The groups of individuals who are differentiated usually are conceived to be those who have mastered certain skills on the one hand and those who have not on the other. According to Millman (1970), norm-referenced procedures for assessing student progress are inappropriate regardless of how instruction is individualized. A report of one aspect of a continuing effort in the area of individually prescribed instruction (IPI) clearly exemplifies the relationship between criterion-referencing and the individualization of instruction:

> Criterion-referenced tests are constructed so that . . . the teacher can readily determine each child's degree of competency within each curriculum area by testing for the presence of specific behaviors. Testing the terminal objective within each grouping may then serve as a placement test. If the child can demonstrate mastery of that terminal objective, and if the hierarchy of objectives is valid, he has, by inference, achieved mastery of all the supporting behaviors. On the other hand, if he cannot demonstrate mastery of the terminal objective, the educational task becomes one of determining the level at which teaching should begin. . . . As the child learns and moves through the sequence, post-tests are used to monitor his mastery of the defined behavioral objectives. This organization offers the teacher a precise

method for tracking each pupil as well as allowing for specific instructional strategies for each objective (Rosner, 1969).

Evaluation of Individualized Instruction

In the previous section of this review, the usefulness of criterion-referenced measurement for assessing the effectiveness of individualized instruction strategies was mentioned. The basic question is "In what ways can the outcomes of criterion-referenced measures be utilized in evaluating the effectiveness of individualized instruction in terms of the learner?"

Bloom and others (1971), in their *Handbook on Formative and Summative Evaluation of Student Learning,* provide much useful information in answering this question. They distinguish three types of evaluation: diagnostic, formative, and summative. Each of these types of evaluation, in their terms, is based upon outcomes from the administration of criterion-referenced measures. The diagnostic evaluation is based on the outcomes of administering a measure to students just prior to the instructional process. Formative evaluation is based on the outcomes of administering such measures at varying points throughout the instructional process. Summative evaluation is based upon the administration of these measures at the conclusion of instruction. The major distinction between the types of evaluation as mentioned herein is upon their differential purposes.

The purpose of diagnostic evaluation is to determine a student's readiness for a specified set of learning tasks, and to determine an appropriate point for a student's entry into that particular set of learning tasks. Formative evaluation, on the other hand, is conceived to be a monitoring device to determine how far the student has progressed in mastering certain learning tasks, to assess the nature of the remaining tasks within the predetermined set, and to prescribe alternative instructional approaches to help the student in mastering those tasks. Summative evaluation is used to determine the degree to which a student has mastered the complete set of objectives upon which the instructional unit was based, for the purpose of either grading the student or determining the degree of effectiveness of the instruction.

In viewing education from the "systems" concept, there can be one diagnostic evaluation, one summative evaluation, and several formative evaluations during the course of any one student's progress through his educational experience. Viewed in this way, schools have a set of hierarchical objectives toward which students are directed. The ultimate objectives form the basis for the summative evaluation and the set of objectives at each lower level form the basis for each of the formative evaluations. In reality, however, this view usually is not taken. The more realistic view of breaking down a total school experience into courses, years, or semesters is more feasible. In this condition, summative evaluations of courses, a total year of experience, or a semester's set of experiences become diagnostic evaluations in terms of the ultimate objectives.

Another confusing issue in evaluation of instruction is the use of the same information, that derived from a criterion-referenced measure, for

two different purposes: monitoring of the student's progress, and inferring the degree to which a specified set of instructions is effective for a particular student.

> Good instructional planning is based upon an assessment of the skills possessed by the intended student population, and the evaluation of instruction obviously must be based upon measurement of its outcomes. The mere information that learners have or have not acquired given behaviors serves no useful educational purpose in itself. However, this information can be used to make sound decisions about instructional treatment (Sullivan, 1969).

Sullivan's focus is upon the assessment of the effectiveness of instructional treatments or strategies. An equally important use for measurement information is the monitoring of a student's progress through a given instructional unit. Both of these views, in the authors' opinion, are of equal importance in assessing the quality of a sequence of instruction. In this regard, Bloom (1968) has specified two contrasting methods of assessing the quality of instruction. The first is an assessment of quality in terms of good and poor teachers, teaching, instructional materials, and curriculum—all in terms of group results. The other method of assessing instructional quality is expressed in terms of the degree to which the presentation, explanation, and ordering of elements of the task to be learned approach the optimum for a given learner.

The current tendency in instructional evaluation appears to be determination of the most effective instructional strategy in order to achieve a given set of objectives for an individual student. This is the central notion of research on individualized instruction.

Designs for Evaluating Individualized Instruction. In one sense, all research exploring any aspect of the broad scope of individualized instruction could be considered evaluative in nature. In order to determine the most effective instructional strategy, media utilization, or sequencing of objectives, for a particular student, one must evaluate.

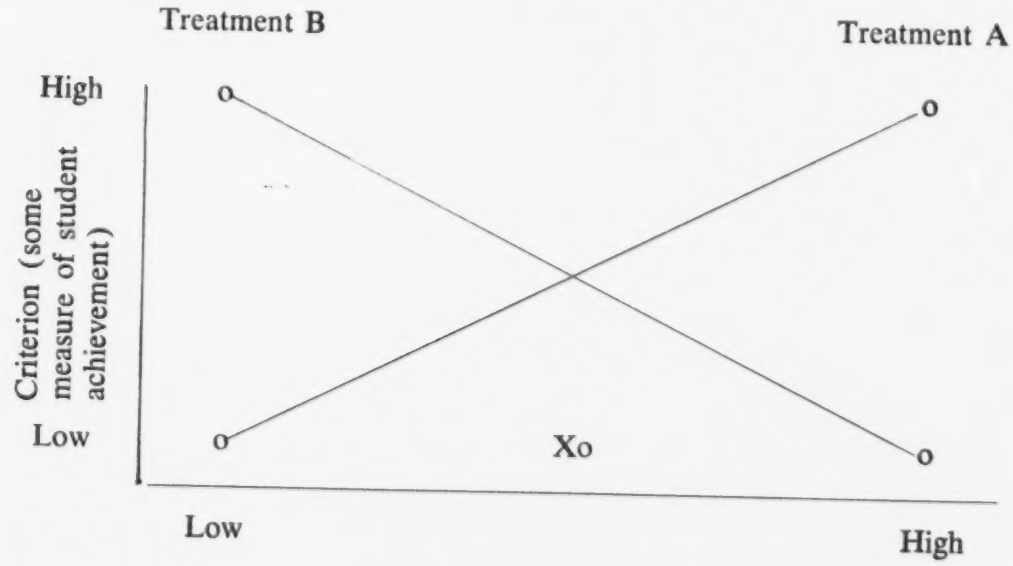
Typical examples of the design of instructional evaluations have proven to be of little help. The thousands of comparative studies designed to explore the differences in effectiveness between instructional method A and instructional method B for a particular group of students given a common set of instructional objectives is a good example. "A researcher merely comparing one instructional method with another may be unable to demonstrate any differences in learner's achievements until he takes into consideration certain student characteristics" (Bloom, *et al.,* 1971). Travers (1962), in evaluating a number of studies exploring the outcomes of comparing one instructional methodology with another, concluded: "They have contributed almost nothing to our knowledge of the factors that influence the learning process in the classroom. Many of them do not even identify what the experimentally controlled variables are." The common objection here is that in attempting to determine what instructional methodology is the most effective for all youngsters in any

particular class, school, or grade, one is asking the wrong questions. More appropriate questions in a research frame are those which relate to the degree of effectiveness of selected instructional strategies with selected kinds of students. What instructional strategies are most effective for a group of youngsters with given characteristics, as compared with those youngsters with another set of characteristics?

A relatively simple specific design of this type has been proposed by Bloom and others (1971), which they characterize as "an ideal, hypothetical pattern of interaction between pupil characteristics and type of instructional treatment." Figure 1 represents the core of their recommendation. It conveys a two-by-two factorial design with two instructional

Figure 1

A design recommended by Bloom, Hastings, and Madaus (1971)



treatments and two groups of students, one characterized by low spatial aptitude and the other characterized by high spatial aptitude, the criterion remaining fixed. In exploring the formative evaluation of industrial education, Baldwin (1971) introduces an evaluative design that could be utilized in extending the Bloom design. Baldwin utilizes types of objectives as a factor (a four-level factor as given: knowledge, understanding, application of knowledge, and application of understanding). Although spatial aptitude is utilized as an example of a student characteristic which could be used in an evaluative design, this notion certainly could be extended

to include many other kinds of variables. These variables could include various dimensions of aptitude, interest, attitude, personality, and other personal variables; and a variety of background factors such as socioeconomic, status, family background, and educational experience (Lindvall and Cox, 1969). As has been pointed out, a major handicap in trying to incorporate this variety of student characteristic information in an evaluation of individualized instruction is the lack of theoretical knowledge concerning the relationship between these variables and the instructional treatment (Lindvall and Cox, 1969).

There are at least three factors which must be considered in designing an instructional evaluation. These factors are:

1. Type or level of instructional objectives: types such as affective, cognitive, or psychomotor; levels within cognitive, such as knowledge, comprehension, application, analysis, synthesis, or evaluation.
2. Student characteristics: aptitudes, prior achievement, interests, attitudes, other personal variables; along with socioeconomic status, type of family background, prior educational experience, and prior occupational experience.
3. Instructional strategies: types of mediation, sequencing, pacing, and packaging of materials.

Of the thousands of evaluative designs that could be conceptualized on the basis of these three factors, ranging from extremely simple to the very complex, there are relatively few different evaluative designs in the literature. The range of evaluative designs is extremely small, particularly in vocational and technical education.

The most common design found in the vocational and technical literature compares a particular strategy such as programmed instruction (a complex variable in itself) with what is typically called "traditional instruction." Students with a wide range of abilities, interests, and achievement are sometimes randomly assigned to the two instructional treatments. The instruction is directed toward those objectives which usually are appropriate for the programmed instruction sequence, but not for the "traditional instruction" whatever that treatment happens to be. The findings of this particular type of evaluative study are usually invalid. Not only do they ask the wrong questions, as has been inferred previously, but they also suffer from the following shortcomings: 1) the "traditional instruction" is usually not described and is left to the imagination of the reader (Stickell, 1963; and Travers, 1962); 2) the criterion test which measures the degree to which students meet specified instructional objectives is usually appropriate only for the assessment of the programmed instruction and not for the traditional instruction (Eisner, 1969; and Sullivan, 1969); and 3) there is no attempt to explore the interactive effects (Bloom, *et al.*, 1971; Briggs, 1970; and Travers, 1962).

The only acceptable evaluative designs are those which in some way take into account the three factors mentioned previously. This can be

accomplished in many ways varying from very simple to more complex designs. The one restriction limiting the number of possible designs is that the evaluator is not allowed to identify one group of students who are to represent the general student population. He must either look at one particular segment of that population, characterized by a certain level of aptitude or achievement or a particular kind of interest; or he must identify subgroups in the general student population such as those with a particular kind of interest or a particular level of aptitude. Several possibilities are listed below:

1. Given a particular instructional strategy (I_1) and also given a particular type of objective to be achieved (O_1), how effective is I_1 in achieving O_1 for two groups of students (S_1 and S_2), S_1 being characterized by high verbal aptitude and S_2 characterized by having low verbal aptitude?
2. Given a group of students who are characterized by a low need for achievement (S_1), and given a specific set of instructional objectives to be achieved such as the application of selected physics principles (O_1), what is the differential effectiveness of two instructional strategies both designed to achieve those objectives (I_1 and I_2) for S_1?
3. Given a selected instructional strategy designed to achieve knowledge-type objectives and comprehension-type objectives (I_1), and given a group of students characterized by a low numerical aptitude (S_1), how effective is I_1 in S_1's mastery of the knowledge-type objectives (O_1) as compared with the comprehension-type of objectives (O_2)?
4. Given two instructional strategies (I_1 and I_2) designed to achieve a whole range of instructional objectives (O_1, O_2, and O_3), and given two types of students (S_1 and S_2), the first characterized by a history of high achievement level and the second characterized by a history of low achievement level:
   a. Are I_1 and I_2 equally effective in achieving the whole range of objectives for S_1 and S_2?
   b. Do S_1 and S_2 equally master the whole range of objectives for both I_1 and I_2?
   c. Are O_1 and O_2 equally mastered by the two groups of students given the two instructional strategies?
   d. Is one instructional strategy (I_1 or I_2) more effective than the other in achieving the whole range of objectives for S_1 rather than S_2?
   e. Is one instructional strategy (I_1 or I_2) more effective than the other for the two groups of students in achieving O_1 type objectives rather than O_2 type objectives?
   f. Is one type of student (S_1 or S_2) more likely to master O_1 type objectives than O_2 objectives for both instructional strategies?

As these possible designs have been listed from one through four, it is obvious that increasing amounts of information can be obtained as the design becomes more complex. Where it is possible to manipulate each of the three factors, an increasingly larger amount of information about the effectiveness of strategies for particular kinds of students and objectives is possible. Jacobs, *et al.* (1966) describe more specific designs of this type.

Examples of Individualized Instruction Evaluations. The authors reviewed several major efforts of individualized instruction, including evaluation, which it might be helpful to describe. These efforts range from very scientific and controlled experimentation to extremely haphazard and uncontrolled evaluative attempts.

Esbensen (1968) in reporting experiences at Duluth, Minnesota in individualizing instruction, refers to some typical evaluative information:

> It is difficult to state with assurance that individualized instruction is indisputably superior to traditional forms of schooling. As measured by a traditional kind of standardized achievement test . . . the results show a general standoff in performance. Moreover, we have been unable to find suitable tests in such important areas as creativity, improvements in study habits, growth and acceptance of responsibility, and the like.

In pointing to some specific effects of individualized instruction he provides us with the following kinds of information:

> When a school principal reports a drop in absenteeism among project students, this may tell us something about student attitudes toward school. When a district survey revealed that while school window breakage in the district as a whole increased, window breakage for project schools in the inner-city core substantially decreased, this fact may tell us something about student attitudes toward school. . . . After several weeks in an individualized instruction program a young mentally retarded child who had a bed-wetting problem was cured. A sixth grade boy, an extremely shy and withdrawn student when he first enrolled in the individualized program, is now chairman of a class oceanography project and consultant to an aerospace project that plans to launch four multistage rockets during the current school year.

Edling (n.d.) describes the types of evaluative information utilized in the 46 individualized instruction efforts he reviewed (including the Duluth project). They include: standardized tests of various types; teacher-made tests; tests accompanying instructional packages obtained from Project PLAN, the IPI (Individually Prescribed Instruction) project, or other multi-faceted efforts; and student self-evaluations.

Regarding the use of standardized tests, to evaluate individualized programs, as demonstrated in the previous two efforts, a significant position is offered:

> The difficulties associated with the use of standardized tests for evaluating educational programs are well known. Faced with results of no significant difference when comparing his program with the traditional ones, the developer of a new curriculum indignantly, and often justifiably, denounces the validity for his

> curriculum of the very test he selected for evaluation purposes. The standardized, he claims, was constructed to measure the content of textbooks and curriculum guides in use prior to the development of his new curriculum. In actual fact, standardized tests are not constructed to sample very specifically the content of any single instructional program, although quite frequently they sample less adequately the specific content and behaviors featured in new curricula. . . . Because objectives vary to some extent from program to program, it will be difficult to ever develop a method for comparing programs that will be completely satisfactory to the sophisticated researcher or even minimally acceptable to the curriculum developer whose program fails to show superior results (Sullivan, 1969).

Lindvall and Cox (1969), in describing their continual evaluation of the individually prescribed instruction (IPI) project at the University of Pittsburgh Learning Center, describe in detail the IPI evaluation system. They conclude that "an individualized system can achieve its true potential only if all of its elements are evaluated on a continuing basis and if information acquired is used as feedback for improvement." They describe the use of placement tests, unit tests, curriculum-imbedded tests, unit post-tests and prescriptions in each of the IPI systems; yet they recommend that the basic function they describe could fit into a general model as found in other individualized programs.

Lindvall and Cox also briefly describe Project PLAN, a project of the American Institutes for Research for individualizing instruction. They indicate that the planned evaluation procedure uses extensive pupil data in determining what the pupil should study and in monitoring each individual's progress through the curriculum. They contend that the evaluation system built into Project PLAN should become increasingly more adaptive to individual pupil needs as our knowledge regarding the relationship between individual differences and learning is acquired.

Summary

Sullivan (1969) in carving out the future of evaluation in individualized instruction makes the following comment:

> Remarkably few major projects in the development of new curricula or in the improvement of classroom instruction have attempted to employ systematic assessment of learner performance on precise instructional objectives as a means for instructional improvement. Consequently, objectives-based techniques for conducting formative evaluation efforts with new curricula and for individualizing classroom instruction are in the early formative evaluation stages themselves. Their refinement is contingent upon evaluation of their use in the development of instructional programs and in ongoing classroom instruction. Once such procedures have been sufficiently refined, there will still be a need for summative evaluation to compare programs that incorporate them with those that do not. Like the methods and materials in any instructional program, the value of these evaluation procedures ultimately must be judged by their effects on student performance.

STUDENT CHARACTERISTICS RESEARCH

Research which focuses on student characteristics in the individualized instruction process has the potential to contribute significantly to the improvement of instructional design. This is particularly true in view of the increased concern about developing vocational services and programs to meet the needs of disadvantaged and handicapped persons (Office of Education, 1970). There are, of course, several important considerations which cannot be overlooked when this area is being investigated. Within the context of individualized instruction, student characteristics are but a single component of the many which constitute a viable individualized instruction model. Cronbach (1967) suggests a learning theory whose propositions would state the conditions of instruction best for pupils of certain types with conditions and types described in broad dimensions. He further specifies that an important aspect of this theory would be the concern about aptitude-treatment interactions. DiVesta (1971) indicates that learning research is shifting toward the study of individual differences as they interact with various treatments, that is, "Which treatments (educational or instructional strategies) have greatest payoff for subjects with which characteristics?" Based upon a concern about the conflicting results from learner characteristics-instructional methods studies, Tallmadge and Shearer (1968) specify a conceptual model which may be useful in guiding further research. In this model, consideration is given to type of learning, type of instruction, and type of subject matter.

It appears that research dealing with student characteristics should perhaps involve more than one dimension. By examining a greater number of variables as they interact with each other in the instructional process, more meaningful information can be gained regarding the effect of student characteristics.

Tyler (1965) identifies a number of the dimensions which may vary from individual to individual. Measurable differences exist in physical size and shape, physiological functions, motor capacities, perceptual sensitivity, intelligence, achievement and knowledge, interest, attitudes, and personality traits. For the purposes of this review, several of these characteristics have been grouped together. First, an examination will be made of research findings related to the differential effectiveness of individualized instruction for students with varying abilities. Second, those studies will be reviewed in which instruction has been demonstrated to be effective with student groups of varying backgrounds. Third, those research studies which have investigated the affective characteristics of students as they relate to performance will be reviewed.

Student Abilities

The adaptation of training to individual differences was investigated by Taylor and Fox (1967). Training tasks of varied complexity were presented under laboratory conditions to newly inducted basic trainees in the Army, who were divided into high, middle, and low groups based upon

their Armed Forces qualification test scores. Learning performance was found to be directly related to aptitude level. For some tasks, group differences were found in rate of learning only, and for other tasks, the groups differed in learning rate and in final levels of performance. Performance was found to be related to training method for both high and low aptitude groups. The low aptitude trainees did poorly on all tasks, taking an average of two or three times as long to learn as the high aptitude trainees.

Melaragno (1966) studied the adaptation of self-instructional materials to individual differences. In the first phase, an existing program was administered to the subjects individually or in small groups. The results provided an empirically determined adaptation procedure based on two pieces of information: subjects' performance on the learning task, and subjects' pretraining abilities as measured by five pretests. During the second phase these two procedures were compared with each other and with the control condition in which all subjects received a common instructional sequence. Results supported the use of procedures which adapt instruction to individual differences. It was concluded that more research is needed on branching and prediction strategies.

Aptitude level and the acquisition of skills and knowledges was examined by Fox and others (1969). Groups of high, middle, and low aptitude subjects were trained on different combinations of eight training tasks. Instructional methods were selected to maximize the opportunity to learn for the low aptitude recruits. Where practical, instruction was automated to insure standardization and clarity, using audiovisual presentation including slides and video tape. All instruction was conducted individually with an instructor present to answer questions and provide immediate knowledge of results after each response. In general, the low aptitude subjects were slower to respond, required more training time to attain a specified criterion, needed more guidance and repetition of instruction, and were decidedly more variable as a group than the middle and high aptitude subjects. The learning performance for the middle aptitude subjects was typically between that of the high and low aptitude groups but more like the high aptitude groups. Follow-up data on subjects' performance showed the same general relationships.

A study of the relationship between entering characteristics and time required to achieve unit mastery was conducted by Yeager and Kissel (1969). Relationships between unit pretest scores, number of skills to be mastered in the unit, student intelligence quotient, age, units previously mastered, and the amount of time required to complete one of four units was investigated. Results indicated that the number of days required to master a given unit was related to the student's initial entering state, with most important factors being the student's unit pretest score, the number of skills that must be mastered, and the student's age.

Silberman and others (1962) explored the interaction between programmed teaching devices and individual characteristics of high school students. The variables examined were the achievement characteristics

(over, normal, and underachievers) of approximately 250 students, and the conceptual forms for the program. The research did not aid significantly in the identification of dimensions for specifying the learning task, method, and student. It was concluded that attempts to keep methods within the programmed instruction framework impaired the effectiveness of the instruction.

A study conducted by Bush and others (1965) explored the hypothesis that there is a relationship between patterns of learning ability and the amount learned under different instructional conditions. Data gathered tended to support the contention that students with relative strength in reading vocabulary are superior to students with relative strength in mathematics fundamentals when both are required to learn from instructional conditions that are highly verbal. On the other hand, students exhibiting relative strength in mathematics fundamentals tend to learn more efficiently in individual laboratory situations than do students showing relative strength in reading vocabulary. No comparable patterns were revealed with the scores from the *Wechsler Adult Intelligence Tests* or the *Airman Qualification Examination.*

A series of studies by Sticht (1969) focused on learning by listening in relation to aptitude, reading, and rate-controlled speech. Three studies examined the ability of high and/or low aptitude men to discriminate and comprehend listening materials presented at rates comparable to those used in silent reading. Two additional studies were aimed at determining whether the observed limitations in comprehension of very rapid rates of speech for men at all aptitude levels were due primarily to signal distortions resulting from the process used to accelerate the speech or the rate of speech per se. It was concluded that certain materials may be presented as effectively through listening as through reading for men of both average and low aptitude. Additionally, moderate degrees of speech compression may improve the listening efficiency of men with high average, average, and low aptitudes. The findings generally indicated that in some instances listening materials may be as useful as reading materials for training men of all aptitudes. Additional data suggests that the potential motivational value of listening materials in inducing men to study should be explored.

Pieper and Folley (1967) examined the effect of ambiguous test results on troubleshooting performance. Subject aptitude had the greatest effect on speed (isolation time) and accuracy of identifying the guilty component (identification errors). On the other hand, aptitude had no effect on the application of the troubleshooting strategy since both medium and high aptitude subjects used the same number of tests in solving the problems. Ambiguity of test results affected speed, accuracy, and application of the strategy. As the percentage of ambiguous test results increased, more time was required, less accuracy was attained, and a greater number of checks were used in solving problems.

Wodtke (1965) investigated the interaction between student aptitude and scrambled versus order sequence of computer-assisted instruction.

Findings of this study indicated that it is the academically talented student that suffers most from a highly disorganized, scrambled sequence of instruction. This did not support the assumption that the high ability of gifted students compensates for ineffective instruction such as a poorly written textbook, or a poorly prepared instructional program.

Research conducted by Gilman and Moreau (1969) dealt with some of the relationships between verbal content in computer assisted instruction and verbal abilities of students. The subjects consisted of tile-setting and plumbing students at a community college. The experiment used two versions of a program, one with high verbal content and one with low verbal content. Results indicated a lower correlation between intelligence and learning on the part of the students who studied the low verbal content program. The authors recommended a greater effort to program materials with the lowest possible verbal content so that low ability students can more adequately comprehend the programs.

As part of an investigation by Armstrong (1967), selected criterion measures were correlated with mental ability in order to identify possible relationships which might have implications for programmed instruction and individualized instruction. It was concluded that both methods of instruction were equally effective for both low and high potential achievers. No significant correlation was found between mental ability and achievement or between mental ability and retention for either method.

The effect of special practice frames upon programmed instruction performance was examined by Melching and Nelson (1966). Students in this study represented two levels of verbal ability. Practice frames enabled the subjects to proceed through the program at a faster rate per frame, make fewer program errors, and score higher on a recall type achievement test. Subjects of higher verbal ability were able to proceed through the program at an even faster rate, make fewer program errors, and exhibit higher scores on all achievements measures. Melching (1965) examined the relationship between measures of ability and programmed instruction performance. Data from several programmed instruction studies served as the basis for the results. With few exceptions, each ability measure tended to be substantially related to each measure of programmed instruction performance.

The effect which visual-haptic aptitude has on student-teacher interaction and mechanical drawing achievement is reported by Erickson (1967). The data revealed that students who were instructed by a non-visually oriented teacher attained a mean level of achievement which was significantly higher than the mean level of achievement attained by their counterparts who were instructed by visually oriented teachers. Additionally, the students identified as visually oriented were, as a group, the highest achievers, while those identified as haptically oriented were the lowest achievers.

Student Background Characteristics

Studies focusing on student background characteristics are not as prevalent as those which examine student achievement and abilities. Haskell

(1969) studied the effects of personality characteristics upon learning by various modes of instruction. A treatment by levels (of personality) analysis of covariance design was used with achievement test scores serving as the criterion. No significant differences were found in the mean achievement of groups who received the various treatments. Significant differences in achievement were found among groups of subjects whose personality was categorized as low, medium and high on the restraint, emotional stability, and masculinity scales. There were significant interactions between instructional methods and levels of subjects categorized as low, medium and high on the general activity and friendliness personality variables. It was concluded that programmed instruction appears to hold promise for students who are agreeable and easy to get along with and/or who are inclined to be slow and methodical, while more aggressive students appear to perform better under conventional instruction. The general activity and friendliness scales of the *Guilford-Zimmerman Temperament Survey* appears to be useful in prescribing maximally effective instructional methods for individual students.

Tallmadge and Shearer (1967) conducted a study to determine whether training effectiveness could be increased by employing training systems which differed in design and use as a function of identifiable student characteristics. A complete factorial experimental design was employed involving a control and two experimental training methods and 16 measures of trainee aptitudes and interests. Large and statistically significant achievement differences were found to result from the three training methods with the "understanding" course superior to both other versions. Interactions between training methods and learner characteristics were not significant. It was concluded that the lack of interactions resulted from the heterogeneity of subject matter and skill content of the course and interaction of content with training methods.

Three experiments reported by Briggs (1961) dealt with the scheduling of training conditions for the acquisition and transfer of perception motor skills. Results suggested that one can provide either too much or too little prior training; the group receiving a "medium" amount of such training was superior on the non-aided tasks to groups receiving a relatively small or a relatively large amount of training. The results of two additional studies in the series specified that inappropriate scheduling of augmented feedback conditions and feedback which is not augmented at all accounts for negative performance.

Fedel (1965) reported some of the variables which are related to individualized instruction procedures in typing and shorthand. Data indicated that students who had taken junior high typing had a higher average speed than students who had not. It was also noted that sex and intelligence were not related to typing speed.

Lecture-discussion and self-directed study methods were compared in a study conducted by MacNeil (1967). The methods were compared for relative effectiveness in attaining the objectives of a course on nutrition; for possible relationships between student personality characteristics

and achievement of course objectives with either method; and for the attitudes of students expressed in terms of satisfaction toward the course and toward the method of instruction. A significant difference favoring the lecture-discussion group was found. Students with either high or low ratings for autonomy showed higher levels of achievement when taught by a lecture-discussion than did those similarly classified in the experimental group. Achievement of course objectives was directly related to student overall scholastic ability, including reading comprehension and listening comprehension. Neither of the methods compared indicated any significant advantage to students within specific ability levels in respect to achievement of course objectives.

Student Affective Characteristics

The last series of studies to be included in this section are those dealing with the affective characteristics of students. Variables included in this category consist of those which are temporary, such as the personal variations resulting from situational conditions (i.e. attitude toward a situation, anxiety, etc.).

Miller and Rosenquist (1965) reported on the effects of programmed instruction on attitude and achievement. Students enrolled in an electricity class and an electronics class were studied for one semester to evaluate the effectiveness of using the Autotutor Mark II which had been programmed to permit individual study. Additionally, initial learner attitude toward programmed instruction and subsequent attitude shift as a result of continued exposure to this instructional technique were evaluated. No significant differences in achievement were noted in the three groups as a result of the instruction. The attitude evaluation of the programmed instruction group showed a shift from a highly positive to a definitely negative reaction. The students were most critical of programmed instruction in the area of quality of explanation. It was concluded that the treatment failed to help students build desirable attitudes toward programmed instruction.

Ugelow (1962) presented a literature review dealing with motivation and the automation of training. A selective review of the literature on knowledge of results, praise and reproof, competition, task interruption, and readability suggests techniques for controlling such participation. Potentially useful applications of motivation principles are discussed by the author.

Development of an instrument to assess student attitude toward shop and laboratory instruction is described by Finch (1969). The Likert-type instrument was designed to assess attitude toward a specific period of instruction such as an hour, day, week, or month. Validity and reliability data are reported in detail. Results of the development suggest that attitude may be related to concurrent or subsequent behavior and that students' attitudes toward instruction may vary in accordance with the particular instructional environment.

Wodtke, Mitzel, and Brown (1965) investigated student reactions

to individualized computer assisted instruction. Following an initial session of computer assisted instruction, each student completed a student reaction inventory which was modeled after Osgood's Semantic Differential. Attitude scores indicated that some students were highly motivated to do well in the course, while others were flustered by the machinery. Additionally, a correlation analysis was made between student program errors, rate of performance, ability scores, cumulative grade point average, personality score, and score on the student reaction inventory. The correlations generally indicated that students having lower cumulative grade points and lower ability scores tended to rate the course and machine as fast. The data suggested that computer assisted instruction employing optional delays, optional review, and optional remedial work would be beneficial for some students. In a study conducted by Dwyer (1968) student perceptions of the instructional value of visual illustrations used in a programmed textbook were compared with data resulting from a criterion test covering the instructional content. It was concluded that student perceptions probably do not provide a valid indication of the instructional value of visual illustrations used in programmed instruction.

Wills (1965) examined the effects of teaching shop procedures emphasizing speed of performance. Results indicated that students exposed to speed of performance procedures did not differ appreciably in their attitudes toward the course from a group which received no such emphasis. It was noted, however, that the speed of performance group produced a greater quantity of work with more errors and less economy of materials.

Neidt and Meredith (1966) studied the changes in attitudes of learners when programmed instruction is interspersed between conventional instructional experiences. Five parallel forms of a Likert-type attitude scale were administered in counterbalanced order to 70 airmen studying radiation detection and 53 airmen studying camera repair. Both courses included several weeks of lecture, a program unit, and several more weeks of programmed instruction. Student attitudes were significantly more favorable during the programmed unit in both courses. Changes were considerably more pronounced for the 17 highest ability students.

Summary

The studies which have been reviewed that deal with various student characteristics are indeed few. This is particularly evident in the areas of student background characteristics and affective characteristics.

There are, however, certain trends that can be identified from the studies which have been reviewed. The research generally indicates that positive relationships exists between student characteristics and achievement as a result of instruction. In particular, a strong relationship seems to exist between various measures of student ability and learning. More questionable relationships appear to be present with regard to student background characteristics (i.e. prior instruction and personality). Finally, the absence of student affective characteristics research precludes any firm conclusions in this area. Some relationships may exist between affective

measures and behavior, although the research surface has been barely scratched.

Several final comments relative to student characteristics research are in order. Few of the studies cited have been programmatic in nature. That is, the bulk of the research reported has been concerned with but one or two dimensions of the instructional process. Additionally, the majority of the studies reported in this section were conducted by military training researchers. Evidently the nonmilitary training research community is not too concerned about student characteristics as they relate to the instructional process. This is unfortunate in view of the importance which is placed upon student characteristics as input to an individualized instructional system. Hopefully more relevant research in this area will be generated in the future.

Programmed Instruction

During the early and mid-1960's, programmed instruction was heralded as a revolutionary new approach to teaching which might have the potential to truly individualize the learning process. Since that time, however, the panacea image has been somewhat tarnished. Persons conducting research on learning variables as they applied to programmed instruction found that some programming principles did not always stand up under rigorous scrutiny. Others who made extensive use of programmed instruction in learning situations found that it was not the final answer to questions concerning the meeting of individual needs. Consequently, the studies which follow have been reviewed much less optimistically than they would have been a decade ago.

Although this programmed instruction review is oriented toward vocational and technical education research, one must not overlook the many studies which have been conducted by educational researchers emphasizing other instructional areas. One of the basic references was developed by Stolurow (1961). He examined the principles of programming in terms of many of the relevant learning variables which might be considered when a program is being developed and evaluated. Also included are techniques for writing programs, examples of programming techniques, and a summary of some of the earlier research findings in this area. An annotated bibliography developed by Schramm (1964) provides an excellent review of research on programmed instruction conducted during the early 1960's. A most meaningful addition to the files of the programmed instruction researcher would be the scheme developed by Fry (1963), which classifies variables involved in a programmed instruction situation. The classification would be especially meaningful for a variable or group of variables related to programmed instruction if one wanted to control for the effects of other variables. A more recent document edited by Glaser (1965) takes information on new research in programmed instruction and integrates it with that of the past. This compilation contains over one thousand references. Of particular interest is the review of programmed instruction research which is reported by Householder (1968). He indicates that "research utilizing programmed instruction in vocational, technical, and practical arts education has evolved somewhat more slowly than in other educational areas."

A more recent report by Mayo (1969) attempts to bring together available information on programmed instruction in order to arrive at conclusions about its significance and appropriate role in technical training. The specific focus is upon research and experience within the Naval Air Technical Training Command. Conclusions favor continued activity in programmed instruction and emphasize the importance of individually paced instructional systems. In addition to providing an extensive overview of the characteristics of programmed instruction, Norton (1967b) discusses some of the supporting psychological principles, research findings, advan-

tages, and limitations of this medium. Case studies are presented from schools and industries which are using programmed instruction successfully in occupational education. Criteria for assessing programmed instructional materials are also included. Henry (1968) considers approaches for incorporating programmed instruction into a class environment. Criteria for programmed material selection should include content, style, challenge, length and cost. Warren (1971) focuses on the characteristics of the programmed instruction designer as they relate to quality of the program. Considerable emphasis is placed upon the production of high quality programmed instruction materials.

Programmed Instruction and Conventional Instruction. A number of researchers have chosen to examine programmed instruction as it relates to "traditional" instruction or some conventional approach such as lecture-demonstration or discussion. Gibbs and others (1968) compared conventional and programmed instruction in bookkeeping. The programmed instruction group scored significantly higher on all three of the post-tests and also experienced a 43 percent reduction of learning time.

Programmed and lecture discussion methods of teaching farm credit to high school youth and adults were examined by Hull and McClay (1965). In the first phase of the study the lecture-discussion method of teaching resulting in significantly greater gains in knowledge; however, it was noted that some lecture-discussion teachers used twice as much time as did the programmed-instruction teacher. When the amount of time was controlled during phase two of the study, there was no significant difference between the mean scores for each method.

Programmed learning in extension training was examined by Hyman and Marsh (1964). Findings indicated that programmed self-instruction was as effective as workshop instruction in increasing extension agents' knowledge of the radio, developing more positive attitudes toward use of the radio in extension teaching, and changing the agents' concept of their ability to do radio teaching.

Aiguirre (1966) studied the programmed instruction-demonstration and illustrated lecture-demonstration methods of teaching engine lathe principles and operating procedures. The author concluded that the method of instruction did not have a significant effect upon achievement, engine lathe manipulative performance, or retention.

The purpose of research reported by Ballard (1966) was to determine the extent of achievement and retention of learning as a result of an instructional unit on wood joinery. The unit was taught by two methods —programmed instruction, and lecture-discussion illustrated by color slides. Results revealed that students taking their initial college course in woodworking retained cognitive information relative to wood joinery better when taught by the programmed instruction than by listening to slide lecture lessons. Additionally it was reported that achievement of learning was greater when teaching was provided by programmed instruction over the subject matter content of dowel reinforcements and wood joints.

Programmed versus conventional instruction as preparation for laboratory performance was investigated by Campbell (1969). Pupils who studied the program scored significantly higher on the written test than those who studied by the conventional method. However, no significant difference was found between scores on the performance test.

Curl (1961), when he explored the effectiveness of a self-instructional method for teaching equipment operation, concluded that perceptual-motor skills relating to the operation of certain types of photographic equipment can be taught individually by means of a self-instructional, demonstration-practice-test type of program. He also commented that necessary verbal cues can probably be presented as effectively in caption form as with a recorded commentary.

Manchak (1965) made an experimental comparison of two methods of teaching a perceptual-motor task. The findings indicated that the programmed material produced statistically significant differences in overall achievement between the two lower ability groups. There were no significant differences with upper ability subjects. Likewise no significant differences in performance were found between the two groups.

Student achievement in a manipulative skill when taught by lecture-demonstration and modified programmed instruction was examined by Seal (1969). The research involved a comparison between a traditional and an experimental method to determine student learning of beginning welding. There were no significant differences in student achievement for any of the tensile tested welds. The experimental group, however, was significantly superior on the destructive bend test.

A study conducted by Simich (1965) compared a self-instructional course and a correspondence course with a programmed method of instruction. Findings indicated that students in the correspondence course group gained significantly more knowledge than students in the programmed group. A three week delayed examination revealed that there was a substantial gain at the upper and lower ability levels in each of the treatments.

Hughes and McNamara (1961) compared the learning achievement of employee classes taught by programmed textbooks with that of classes taught by conventional classroom instruction. Although a difference was found between the control and experimental group achievement means even after adjustment for Programmer Aptitudes Test scores, this could have been caused by a difference in variance of the groups. It was also noted that the mean completion time for the programmed instruction classes was 8.8 hours, with large individual differences, while the control classes were 15 hours.

Approximately 13,000 basic military trainees were used in a field experimental study of programmed instruction on manipulative tasks (Folley, *et al.*, 1964). The modes of training included lecture-demonstration, a printed linear program with or without an answer sheet, and an audiovisual program presented by an audiovisual device or a printed booklet. Also evaluated was a condition in which the trainees tried to

perform the final task and were assisted as required. The content of the training was varied by providing training on assembly only, disassembly only, or both. The final criteria were the time and number of assists required to disassemble and assemble the M-1 carbine. No modes of training seemed superior to the other modes. The audiovisual program presented in the printed booklet seemed somewhat inferior. Training on only the assembly of the carbine resulted in as good a performance as training on both assembly and disassembly. Findings probably can be generalized only to relatively simple procedural type tasks.

Cochran (1966) reports on the evaluation of an experimental lettering program. Results revealed that all three methods of instruction (conventional, direct-detailed, and programmed) were equal in teaching the technical knowledges of lettering. However, programmed instruction was superior in the development of practical lettering skills.

A comparison of self-instructional methods and demonstrations and teaching manipulative operations was conducted by Hofer (1963). Written tests covering the knowledge of terminology and procedure were given immediately after instruction and one week later, and indicated that students learned and retained slightly more information when they received instruction from printed programs. It was also noted that 69 percent more individualized assistance was required when instruction was presented by *demonstration* than when presented by programmed materials.

Kopstein and Cave (1962) consider the comparative costs of training with automated and conventional instruction. Three different methods of estimating the cost of a prototype automated course in electronics are compared with the estimated costs of a current conventional course. Costs of automated instruction compare favorably with those of the conventional course regardless of the method of estimation. Further, these costs continue to diminish as the number of students trained increases, whereas conventional costs remain constant. Generalizations related to the economic factors of auto-instruction are discussed in terms of application to Air Force training courses.

The Development of Programmed Instruction Materials. Although this research review does not deal specifically with activities involving the development of programmed instruction materials per se, it was considered appropriate to include several representative studies which deal with the design of programmed instruction. The studies which follow are perhaps representative of efforts to change the behavior of students through the medium of programmed instruction as compared with students who do not receive such instruction.

Coffey and others (1968) described a programmatic effort in the development of self-instructional methods for selected areas of vocational education. The authors report that evaluations of five units supported the relative efficiency and effectiveness of self-instruction in these areas. Studies of the skills of auditory diagnosis in mathematical word-problem solving did not result in units that could be evaluated.

The influence of a set of programmed materials on vocational values

was examined by Grubb (1965). A programmed textbook, *Value and Choices,* which was developed for the study, is concerned with certain aspects of career planning and is potentially an instrument that can be used for vocational guidance purposes. The study was concerned with the influence of three factors on each of the sub-skills included in the *Vocation Values Inventory* (VVI). Major conclusions were that 12th grade males and females who use the programmed textbook value the self-realization aspect of work more than 11th and 12th graders who did not use the textbook.

The value of programmed instruction in the enhancement of the career objectives of high school cooperative distributive education students was examined by Trimpe and others (1966). Instruction for the treatment group consisted of a self-study program in retail food store operations, while the control group was engaged in regular classroom activities. Conclusions were that a majority of the students began with an unfavorable attitude toward retail food distribution as a career objective and the programmed information reinforced these negative attitudes. Students did, however, gain some knowledge about the food industry.

Programmed Instruction as Compared with Structured Group and Individual Instruction Approaches. Several studies have been identified which compare programmed instruction with media or with instruction which is typically individual in nature (i.e., textbook study, shop or laboratory work). Additional studies examine the place which programmed instruction has within the instructional process. Several examples of these studies follow.

Lundy (1968) compared programmed booklets with sound filmstrips in teaching automotive electricity. The data revealed that achievement of learning is greater when teaching is presented by programmed instruction as opposed to instruction given by sound filmstrip. This was true of both initial learning and retention.

The purpose of a study by Bensen (1967) was to compare the relative effectiveness of teacher-prepared linear program instruction sheets in the teaching of manipulative operations. Two experimental groups, each using one of two types of programmed operation sheets, were evaluated and compared with the control group which utilized a standard operation sheet. The findings revealed that the programmed materials had a positive effect in supplementing the group demonstration in teaching manipulative operations. The effect, however, was limited to two of the four variables studied. These variables were the amount of technical knowledge acquired by the student and the amount of assistance required by the learner in completing the job.

Finch (June, 1969) compared selected self-instructional approaches of teaching diagnostic problem solving to automotive students. The equipment-oriented treatment group required the shortest instructional time and its troubleshooting performance was significantly better than the textbook-oriented and programmed instruction groups. Results also indicated that no significant difference existed in troubleshooting knowledge

or attitude toward instruction. It was concluded that equipment-oriented methods might be most effective for teaching complex performance tasks.

The use of programmed instruction with and without self-instructional practice to teach psychomotor skills was studied by Norton (1967a). The data failed to support the theory that programmed instruction can satisfactorily teach psychomotor skills which primarily require the learning of cognitive knowledge in order to properly use motor skills the learner already possesses. Likewise the method used to supplement the programmed instructional materials in the study, namely self-instructional practice, did not produce any significant benefit over the use of the program alone.

An experimental comparison of linear program and standard textbook approaches in teaching basic electronics was conducted by Lease (1964). Students in the program treatment were provided with commercially prepared material in basic electronics, while students in the textbook treatment utilized a textbook especially designed to parallel the program. No significant difference in the effectiveness of the program and the textbook were found as measured by the amount of factual material initially learned or retained after six weeks. Additionally, no significant differences were found in the effectiveness of the linear program and the textbook as measured by the ability of students to apply electronics facts and principles initially learned and to apply facts and principles retained after six weeks.

Stephenson (1969) compared programmed text material with a programmed lecture in teaching lumber measurement concepts. Two experiments were conducted, with the second one replicating the first. For both experiments, a significant difference in the level of achievement was found which favored the programmed text group over the programmed lecture group. It was concluded that junior high school students studying a unit in lumber measurement concepts by programmed instruction can achieve more than students studying the same unit by programmed lecture.

Internal Changes in Programmed Instruction. Several researchers have studied the effects which internal changes in programmed instruction have on learning. These modifications differ from variation in learning strategies in that they deal more with program structure than with learning theory.

A comparison of learning and retention of information learned through the use of linear and branching programmed instruction is reported by Shull (1969). The results of the study indicated that there were significant differences in learning between the linear and branching groups as measured by the immediate post-test. The difference was in favor of the branching group. The difference on the two-week delayed post-test was not significant.

Finn (1965) attempted to determine the effect upon learning of using different question arrangements with a linear program about standard food measuring equipment. The program was arranged into three forms which included: 1) 144-frame linear program, 2) the linear program preceded by 12 motivational questions and including the same 12 questions

interspersed in the appropriate places for participation questions, and 3) the linear program preceded and followed by the same 12 questions used in the second form. It was found that there were no significant differences between the groups on a criterion test which was administered after the program had been completed. It was also reported that the form of program had little effect on the amount of time taken to complete it. Those with high IQ scores tended to take less time to complete the program than those with low IQ scores. Girls had a somewhat positive attitude toward the program, however, neither form of program nor IQ had any noticeable effect on attitude. Additionally, the criterion test score was highly correlated with IQ and with retention test score. IQ score was positively correlated with criterion test score and retention test score and negatively correlated with number of errors on the program.

A study which tested means of improving programmed instruction by adding motivation materials to increase the desire to learn was conducted by Lanham and others (1963). One program consisted of two programmed lessons to teach technical vocabulary related to the commercial letter of credit. A second program added techniques of persuasion utilized in the field of advertising in the first lesson and an incentive in the form of stories using realistic situations in the second. A third program had one lesson on how to learn technical vocabulary and a second on applying the how-to-learn technique. Although learning did result, there were no significant differences between or within treatment groups as to the amount of learning or retention which occurred.

An investigation was undertaken by Klaus (1964) to determine whether step size in linear programs could be defined, measured, and manipulated, and to determine the effects of various step sizes on error rate and achievement for learners at three levels of ability. Step size affected error rate and learning time measures but did not appear to affect achievement measured either by a proficiency test composed of criterion frames from the program or a transfer test adapted from the test originally prepared to accompany each program. Ability level had a substantial effect on error rate, learning time measures, and achievement. Error rate had no apparent relationship to achievement when the effects on ability level were removed.

Research which examined learning set formation and programmed instruction was reported by Reynolds and others (1964). Two different orders of three units of programmed instruction were administered to groups of students who were matched on either intelligence or relevant achievement tests. It was hypothesized that after varied amounts of prior practice in programmed instruction, learning set formation would not be demonstrated by the high intelligence and the high achievement groups, and learning set formation would be demonstrated by the average achievement groups. The data indicated that in a program sequence, error rate is a more appropriate measure than achievement for observing learning set formation. Learning set formation is observable in programmed instruction for all learners regardless of individual differences. Since error rate

differed for some of the experimental groups while achievement remained the same, the results were interpreted to mean that a moderately high error rate program which offers opportunity for correction of response errors may be as effective in producing learning as a low error rate program which confirms correct responses.

As part of a study reported by Bensen (1967) the effects of a technical line drawing as an illustration in each frame of programmed instruction sheets were examined. The study did not substantiate previous findings which indicated that illustrated programs are superior to non-illustrated programs in studies involving the learning of skills. It was felt that any effect that illustrations might have on understanding the concept and aiding in the performance of the operation are cancelled out by instruction received through the demonstration.

Summary. There are several comments which can be made relative to programmed instruction research in vocational and technical education. By far the largest number of studies seemed to center around comparing programmed instruction with "traditional" learning methods. Moreover, many of these studies as well as others which were not included in this section focus on verbal learning as measured by pencil and paper type examinations. Finally, research studies which examine the effectiveness of programmed instruction in promoting attitudinal change are obvious by their absence.

With the aforementioned shortcomings in mind, it is difficult to develop a concrete synthesis of research. Those studies which are reported do, however, seem to have several relevant implications for vocational and technical education. It appears that programmed instruction does, in fact, teach and that exposure to it results in a change in behavior. This change is, of course, dependent upon the programming principles used and the objectives to be attained. Programmed instruction is at least as good as "conventional instruction" if that conventional approach is oriented toward classroom type (cognitive) objectives. The research reported generally indicates that there may be some point at which programmed instruction loses its teaching effectiveness. That is, higher order learning principles (i.e. complex perceptual motor activity integrated with problem solving) might be better taught by means other than programmed instruction. Further research in this particular area is certainly in order. Several of the studies included in this review examined multiple criteria such as time, attitude, verbal behavior, and physical behavior. It is hoped that this approach to research in programmed instruction will continue. Since results seem to indicate that programmed instruction is successful in some applications but not successful in others, it may be necessary to weigh the advantages and limitations of a particular program within a specific learning situation as applied to students having certain entering characteristics.

Computer-Assisted Instruction in Vocational and Technical Education

The use of computers as an integral part of the instructional process has increased quite rapidly since 1959 at which time the first efforts in

this area were made (Hall, 1970). The appeal of computer-assisted instruction stems from at least three fundamental characteristics of the computer: 1) its ability to evaluate students' responses and provide information regarding the degree of correctness of these responses, 2) its capability to allow active response by the student, and 3) the capability of the computer to keep a record of a student's performance and alter the course sequence for that student based upon his immediate task performance (Hall, 1970; Schurdak, 1967).

Computer-assisted instruction (CAI) is an outgrowth of the work in programmed instruction by B. F. Skinner and the efforts of Sidney Pressey with his teaching machines (Hall, 1970). The application of computers to instructional tasks provides a powerful extension of the programmed instruction and teaching machine concepts in overcoming a number of the obstacles in the individualization of instruction. Zinn (1967) lists six instructional applications of the computer: drill, tutorial, simulation and gaming, retrieval and reorganization of information, problem solving with computation and display tools, and artistic design and composition.

Three CAI projects of significance in vocational and technical education were identified. These are: Experimentation with Computer-Assisted Instruction in Technical Education (Mitzel and Brandon, 1965); and Project IMPACT (Seidel, 1968); CAI at the Naval Academy (Koontz, 1970a).

The objectives of the CAI project in technical education conducted in the Computer-Assisted Instruction Laboratory at The Pennsylvania State University were:

1) to evaluate the articulation of computer-assisted instruction with other educational strategies and, by means of careful experimentation, determine optimum ways of presenting core courses in technical education curricula;
2) to prepare curriculum materials for computer presentation with emphasis on the instruction of post-high school students in technical mathematics, engineering science, and communication skills;
3) to train an interdisciplinary group of individuals to prepare course materials and to do research on computer applications in technical education;
4) to disseminate the information and evidence concerning the innovation of CAI and its application to occupational education (Mitzel and Brandon, 1965).

Selected units in technical mathematics, technical physics and communication skills were developed during the four-year duration of the technical education project.

Developed for application to the military, Project IMPACT represents one of the first attempts to provide a multi-purpose CAI system which is economically feasible.

> Project IMPACT is an advanced development effort designed to provide the Army with an effective, efficient and economical computer-administered instruction system. The objective is to

(a) develop two generations of prototype CAI systems with (b) accompanying prototype multipath (branching) individualized programs of instruction (Seidel, 1968).

Given the qualification that this instruction be made directly relevant to a trainee's specific job requirements, it would seem likely that courses developed within Project IMPACT would be applicable to vocational and technical education.

The CAI applications at the Naval Academy involve the use of both teletypewriter equipment and cathode ray tube equipment. Several technical courses such as Underwater Acoustics, Heat Transfer, Electrical Circuits, and Mechanics of Materials have been developed for use in the CAI presentation. Although designed for use by students at the Naval Academy, it would seem that courses such as these would have some application to technical type courses currently being offered in our community college programs. A recent progress report of these CAI efforts by Koontz (1970a) indicates quite favorable results.

There have been several approaches to evaluating the application of CAI material to technical education. Farr and Hogan (1967) report the results of a study designed to determine the degree to which communication skills learned in a CAI instructional unit were transferred to a natural writing task. The sample consisted of 48 post-high school two-year technical students. It was found that no significant transfer resulted from the CAI experience. Schurdak (1967) in teaching a unit of the programming language FORTRAN provides an evaluation of the use of CAI. He indicates that the computer can successfully perform a number of instructional functions. Because of its effectiveness as applied to these instructional functions, CAI could be used to make the teacher's time available for more intimate interaction with the students. Kopstein and Seidel (1967) take issue with the value of Schurdak's evaluation, and strongly question the criteria utilized by Schurdak in his evaluation of CAI. Schwartz and Haskel (1966) utilized a CAI unit to teach basic data processing principles to a group of 79 electronics technicians. The effectiveness of the CAI approach was compared to the effectiveness of the same material as presented through a programmed text. No significant differences in scores on the criterion tests were obtained although there was a significant amount of time saved by those students who experienced the CAI approach. In addition, the attitudes of the students toward the instruction were about equivalent in both groups.

Research conducted in the area of CAI has been plentiful, yet the authors identified very little research with specific implications for vocational and technical education. There were, however, seven studies identified, five of which were conducted by the Computer-Assisted Instruction Laboratory at The Pennsylvania State University. Two of these studies were conducted utilizing a sample of students in plumbing and tile setting at Williamsport Area Community College. The first of these explored the effects of remedial branching as opposed to review branching on student

learning. The CAI unit utilized in this experiment was one developed as part of the technical physics course development. It involved working with measurement units. It was found that students who were branched to a set of remedial frames scored no differently on the criterion tests than the students who were exposed to review frames (Gilman and Gargula, 1967).

A second of these studies investigated the interaction between verbal aptitude and the degree of verbal content included in a CAI unit. Eighteen subjects with low verbal aptitudes were assigned at random to one of two groups—the high verbal content treatment group, or the low verbal content treatment group. Eighteen subjects with high verbal aptitudes were randomly assigned to the same two treatment groups. Based upon the results of a criterion test administered immediately after the treatment, which measured the degree to which the students had learned to use measurement units, no significant interaction was found. It may be inferred that the difference in the performance between the low aptitude group and the high aptitude group was the same in the low verbal content treatment as in the high verbal content treatment (Gilman and Harvilchuck, 1967).

A third study of interest conducted at the CAI Laboratory at Penn State utilized students from the Williamsport Area Community College and a second group of technical students attending the Altoona Campus of The Pennsylvania State University, and was designed to examine the effects of gradient as opposed to full-response feedback (Hall, Adams, Tardibuono, 1967). The students were randomly assigned either to the gradient feedback treatment group or the full-response feedback treatment group, and their learning of an associative task was compared at the conclusion of instruction to examine initial learning, short-term retention and long-term retention. No differences were found between the groups utilizing the three criterion scores. Johnson and Borman (1967) compared the effects of three modes of a CAI unit covering the physics sequence designed for vocational technical students with a limited mathematics and physics background. These three CAI modes were typeout plus slides; audio capability only; and a display mode, where students read material in a booklet and were shown slides. As measured by a criterion test administered immediately after the treatment, each of the three CAI modes resulted in a significantly higher achievement than that observed for the control group. However, no differences were found in the effectivness of the modes. A replication of the experiment (Johnson and Borman, 1967) resulted in the same finding.

The final Penn State study reported with relevance to vocational and technical education was conducted by Wodtke (1965). He investigated the interaction between scholastic aptitude and CAI sequence. There were two types of sequences programmed: a scrambled sequence (a random presentation of the material), and an ordered sequence. This study is reported in the section of this review dealing with "Student Characteristics Research."

Swets (1962) reported on the results of six experiments dealing with an early model CAI system. The programmed task was for the students to learn a series of multidimensional, nonverbal sounds. After examining the effects of various types of responses, types of feedbacks, types of reinforcement, and step size he concluded that, "these procedures produced results that are comparable to those obtained previously with conventional training methods." Swets and others (1964) report the results of a second set of two experiments dealing with the same material on a more advanced CAI system. The variable under investigation was the degree of control that subjects were given over the sequence of their instruction. They concluded that when the subjects were granted control of the training procedure no better final performance was observed than when the experimenter determined the course of the lesson.

In summarizing the research in CAI related to vocational and technical education: 1) only seven studies were identified; 2) of those seven only three involved samples drawn from the vocational and technical student population; 3) of those three using vocational students only two utilized programs based on vocationally-related content; and 4) none of the instructional programs utilized for experimental purposes was examined in terms of occupational validity standards. It should be obvious even to the most unsophisticated reader that the ground has hardly been broken in examining the application of CAI to vocational and technical education. The overwhelming complexity of variables surrounding the interaction between the student and the CAI system necessitates a research effort of such magnitude to be judged impractical in the foreseeable future. Extensive financial support essential in conducting such a research effort is currently not available, nor likely to become available in the immediate future.

Not unlike other comparable educational developments, in order for millions of dollars to be diverted for CAI research evidence of its potential for vocational and technical education must be available. In order to provide such evidence, however, prior millions must be invested to explore the feasibility and effectiveness of an expensive and relatively untried system. Unless the ratio of research and development dollars to program operation dollars in education changes significantly it is unlikely that these initial efforts will soon be possible. It is thus most probable that CAI systems in operation for the military and for industrial training will prove to have the most immediate impact upon vocational and technical education.

Computer-Assisted Guidance and Counseling

In earlier discussion of computer applications and systems approaches to instruction, references to the guidance and counseling functions were avoided. It may be argued that both instruction and guidance are designed to affect some behavioral change in a learner or client, and thus may be conceptualized under the same general rubric. The authors prefer to allow a high degree of similarity between the two functions, yet distinguish

between them in terms of the more traditional distinction between instructional goals and guidance goals (Miller, 1961; Mortensen and Schmuller, 1966).

Cooley (1970) points out that with schools increasing the individualization of their instruction, teachers are likely to become more specialized, and guidance may result as the only function responsible for the individual student's education as a whole. In today's world of education, guidance is more attuned to the macro-system of which the student is a part, than the micro-system of instruction (Grobman, 1968). Given the future evolution of instructional systems approaches to encompass a wider diversity of educational activity including the administrative aspect, it is possible to imagine this distinction dissolving.

Arguments proposed for the individualization of the guidance function are quite similar to those used to establish the need for individualizing instruction. As Cooley (1970) indicates, the guidance effort is directed toward assisting students to adjust to the school as it is, rather than toward modifying the school to take into consideration the personalities of the students (see Bloom, 1968 for a comparable approach to instruction). What is clear is that the need for individualization is as great in the guidance program as in the instructional program, regardless of the idealized functions of guidance.

As a reaction to this situation several efforts to individualize the guidance function were begun in the mid-1960's, utilizing computer-assisted models, systems approaches, and simulated devices. Since much of this initial work was supported by research funds provided through the Vocational Education Act of 1963, the focus of many of these developmental efforts was upon career guidance.

To guide the reader to summary documents of interest to him, the authors present a brief description of six excellent compilations and reviews covering each of these significant efforts, none of which were published prior to 1969.

The first of these sources is a compilation of position papers and project descriptions edited by Weinstein (1969). This publication was an outgrowth of the fourth Symposium for Systems under Development for Vocational Guidance, held at Palo Alto in March, 1968. It is composed of three parts: 1) a focus upon theoretical concerns in the development of guidance systems; 2) the technological problems in the implementation of guidance systems; and 3) descriptions of a sampling of vocational guidance systems which were, at the time of the symposium, under development. These systems included: David Tiedeman's Information System for Vocational Decisions (ISVD); IBM's Education and Career Exploration System (ECES); the American Institutes for Research Comprehensive Vocational Guidance System (VGS); the Systems Development Corporation's Vocational Counseling System (VCS); the Rochester Career Guidance Project (CGP); Impellitteri's Computer-Assisted Career Exploration System (CACE); the University of Oregon Guidpak System; the Willowbrook Computerized Vocational Information System (CVIS); the

Palo Alto Computer-Based Course Selection and Counseling System; and the Bartlesville Total Guidance Information System (TGIS).

As arranged by special editor Vriend (1969), a special issue ("Counseling Technology") of *Educational Technology* was published in an attempt to cover broadly many of the issues and implications in the development of guidance systems. In addition to the presentation of position papers devoted to the varied role of counselors, computers, technology, and systems analysis in counseling and guidance programs, several descriptions of specific projects are included.

The next of these sources to appear chronologically was a review of systems approaches in guidance (Cooley and Hummel, 1969). This review was prepared by the authors as one of 10 such reviews to be included in the special focus of the *Review of Educational Research* on guidance and counseling. It provides a brief analysis of the systems approach, a review of several current system approaches in guidance, and a forecast of future directions. The specific approaches discussed are: the System Development Corporation's Vocational Counseling System; Tiedeman's ISVD; IBM's ECES; Penn State's CACE project; Willowbrook's CVIS; Magoon's problem-solving procedure; Katz's System of Interactive Guidance and Information (SIGI); Hummel's Coordinated Information and Guidance System (CIGS); Rochester's CGP; Krumboltz's work with Career kits; Boocock's efforts with the Life Career Game; and AIR's project PLAN. The authors, in summing up the collective potential of these efforts state: "Panaceas for guidance are no more possible tomorrow than they are today or than they were yesterday. It's a long, hard row to hoe, and the promise of the systems approach is to facilitate the hoeing."

In chronological order, the fourth review was prepared by Perrone and Thrush (1969). The authors present up-to-date developments in the field of information-processing systems related to vocational development and decision-making. The 18 projects reviewed range from tentative prototype developments to operational programs. Because of the brief abstracts presented in the article, the authors provide names and addresses of persons to contact for further information.

During the latter part of 1970 an excellent book reporting the current progress and projected future of computer-assisted counseling was published (Super, *et al.*, 1970). This book "brings together a collection of papers, most of them published for the first time, which give a balanced perspective on developments in computer-assisted guidance and counseling of students and clients." The unique features of *Computer-Assisted Counseling* are its discussion of theoretical and practical issues with regard to a number of the individual projects and its overview of the current status and future directions of these efforts.

The last of the six sources described herein was guest edited by Havens (1970) as a special issue of the *Personnel and Guidance Journal* entitled, "Technology in Guidance." It includes articles dealing with descriptions of ongoing projects and their progress, media in guidance,

issues involving technology in guidance, and privacy as related to personal data systems.

Because of the sparsity of evidence dealing with the effectiveness of these systems, little information is currently available to predict their probable direction. The feasibility of computer applications in guidance and counseling is attested to by the continuation of two ongoing systems in the schools. These are Willowbrook's CVIS and Bartlesville's TGIS. The major emphasis of these two approaches are upon information retrieval, educational and occupational exploration, and educational and occupational decision-making.

With the introduction of the computer into the guidance system the counselor's role must change. Initial trials of several of the computer-assisted programs previously described tend to support the notion that counselors are not prepared to change their current roles. It has been stated that the counselors' reluctance is an outgrowth of the technological nature of these systems (Dworkin, 1970).

Simulation

Concurrent with the design and adaptation of more complex equipment and processes in virtually every occupational area, there has been increased concern about how persons can be better prepared to work in more of these complex environments. Some persons have stated that answers to this question may lie in the domain of simulation. Simulation is not exactly a new approach to teaching complex behaviors. In commenting on the development of simulators for use in military training, Smith and Smith (1966) state that these devices "have developed into highly complex training systems that combine automatic programming of task sequences and multidimensional recording and control of response with dynamic simulation of the task situation."

What then does simulation consist of? An interesting and relevant definition is provided by This (1970). He states that:

> desirable as it may be, it is not always possible to bring reality into the classroom or into the training situation. When this is not possible, we try to replicate in the learning experience the nearest thing we can to the phenomenon of the real world. It does not matter whether we are talking about a piece of equipment or an emotional experience. We call this simulation.

Gagné's chapter in *Training Research in Education* (1962) is especially relevant to persons in vocational-technical education. He initially indicates three things which a simulator does. First, it attempts to represent a realistic situation in which operations may be carried out. Second, it provides its users with certain controls over the situation, and third, it is deliberately designed to omit certain parts of the real operational situation. Gagné goes on to say that:

> a simulator is designed to represent a real operational situation. Additionally, it provides for certain systematic controls over this

situation. In doing this, it necessarily omits portions or aspects of the real situation particularly those of natural variability and unpredictability.

There are several general references which the reader may examine if he desires to pursue the research which has been conducted in this area. The previously mentioned chapter by Gagné (1962) synthesizes much of the earlier research which has been carried out in the military. A research-based discussion by Smith (1966) is of particular relevance to the vocational educator. He details the reasons why training devices should be used rather than actual equipment, and summarizes some of the cost-effectiveness factors which should receive consideration.

McCowan and Mongerson (1969) provide a definitive review of simulation techniques in three broad areas which include gaming, in-basket, and mechanical multi-media. They conclude that "although the cost of developing comparable simulation units is relatively high compared to gaming, in-basket, and group interactive processes, the effectiveness and the utility seem high."

A more recent discussion by McClelland (1970) deals with the extent to which simulation may benefit vocational education. This research based article draws upon a number of the studies conducted by the Human Resources Research Organization. The author contends that much of the work which has been conducted by and for the military services may have relevance to simulation techniques in vocational education.

Research Efforts in Simulation. Several research efforts have been directed toward the application of simulation to instruction in vocational and technical education. Schneeberger (1968) explored the use of computer simulation in teaching farm management. It was reported that the decision exercise which was developed is effective in teaching concepts, complimenting lectures, and reinforcing previous learning.

A study conducted by Lattes-Casseres (1968) dealt with the effectiveness of teaching home management decision-making concepts through simulation. No significant differences were found between the simulation approach and more traditional approaches in terms of cognitive and effective criteria. It appeared, however, that the simulation method taught abstract concepts involved in decision-making as well as the control methods. The trend seemed to be for the traditional method to teach more effectively at the knowledge level while the experimental or simulation method was more effective at the application level. Lack of significant differences may have been due to the quasi-experimental design of the study.

The effectiveness of a non-computer business game in teaching post-high school business problems classes was conducted by Ashmun (1966). The business game approach was compared with a conventional lecture-discussion-problem technique. It was concluded that there were no significant differences in the mean scores of the unit achievement tests between those who received a business game treatment and those who received a lecture-discussion-problem treatment. High ability students in both groups

obtained significantly higher mean scores on the unit achievement tests than did low ability students. Students who participated in the business game reacted in a highly favorable manner to the treatment.

Rozran (1968) studied the application of a military-type computer-based instructional simulation system to a civilian vocational course setting. Significant results were achieved in the electronics course for students who used the simulator and programmed instruction. However, an auto mechanics group that used the simulator did not achieve to any greater extent than a control group that did not receive simulator instruction.

Kelley (1969) developed a farm management game and then evaluated what students learned as a result of playing it. Based upon empirical evidence it was concluded that making decisions and solving problems cooperatively in groups of two or three while participating in an educational game does not result in more effective learning, and that students with school records of low scholastic performance do not demonstrate improved performance as a result of participating in an educational game. Also, the game which was developed did not appear to improve students' abilities in farm management areas such as computing labor income and decision-making. Most students reacted favorably to the educational game in that they found it challenging and enjoyable.

A computer-based business game for use in high school business-related courses was designed and developed by McNair and West (1970). The model was programmed in FORTRAN IV and installed on a time-sharing computer system. Is was established that the model which was developed had the advantages of stability, rationality and controllability, although it was found to be too competitive in the market place allowing the results of teams' decisions to be extremely separated.

The design of a simulated instructional model for occupational education is described by Ogunniyi (1969). The study showed that the focus of all educational simulations, regardless of the designer's orientation, was the provision of realistic instruction. Transfer of training is the main criterion for deciding what to include in a simulation design. A seven process simulated instructional model for occupational education was then designed by the author. The functions of each of the processes are described and guidelines are provided for utilizing the model and for rectifying disfunctionality that may arise.

Meckley (1970) describes the development of simulation materials for use in vocational and technical education leadership training. In addition to presenting a brief description of the types of simulations and the advantages of using this instructional process, examples are given from the leadership training programs which were recently developed by The Center for Vocational and Technical Education at Ohio State.

A simulated vocational training model to educate mentally retarded students for employment in the hotel-motel industry is described by McCowan and Mongerson (1969). Although the model is described in terms of its specific application to preparing hotel-motel aides, the pro-

cedure could be used as a general curriculum model with other groups in a variety of academic and vocational areas.

Summary. There are several characteristics which the aforementioned research studies seem to have. A number of the studies appear to focus upon the development of simulation materials for application in a vocational and technical education setting. Unfortunately, however, few of them have actually focused on some of the variables which have relevance to the simulation process. An exception to the foregoing is the research detailed by McClelland (1970). He describes some of the research being done for the military which deals with internal variations in simulation training.

Of primary concern in the development of simulations is the fidelity which a simulator has and the transfer of training which it produces. Fidelity, or the degree to which a simulation-based training program departs from reality, is of utmost importance to the educator. As stated by Biel (1962) "for the acquisition of particular skills, what degree of fidelity of simulation is required to insure maximal transfer of training to live operations?" Biel states that the degree of fidelity required must be considered with respect to two aspects of simulation. That is, the training designer must decide: 1) what equipment and functions must be simulated, and how precise the simulation must be; and 2) how accurately the stimulus situations on which training is given must simulate real life? As has been seen by the studies which were reviewed, this concern is, in some cases, minimal. Hopefully, future efforts will delve more deeply into the implications of fidelity of simulation, particularly as they apply to transfer of training.

Other Media Research

Reported within this section are research and development efforts utilizing media approaches which do not fit under the categories previously reviewed—computer-assisted instruction, simulation, or programmed instruction. Only those studies which are based on an individualized approach are reviewed. For a more thorough coverage of media research and application, the reader may refer to sources such as Edling (1968), Reid and others (1967), and Swanson (1965).

Multi-Media Approaches. The authors reviewed a number of attempts to devise individualized instructional programs which were characterized by their designers as multi-media approaches. Because of the dangers inherent in using such a term without specifying its characteristics, the authors have selected a definition and brief description of the term consistent with the approach taken herein.

> The term, multi-media, means a combination of various types of media arranged so as to provide appropriate presentational capability to realize the objectives and content of a lesson through eliciting desired pupil responses. The key factor in a properly designed multi-media arrangement is not simply the use of more than one kind of audiovisual device. It is the interre-

lationship of the media used in order to capitalize on the distinctive characteristics and capabilities of each, making them mutually supportive in the creation of a new learning environment (Haney and Ullmer, 1970).

Rhode and others (1970) have recommended a media configuration which could serve as a multi-media base for an individualized instruction system. The configuration they propose takes into consideration cost factors, support requirements, and instructional flexibility.

A completely automated multi-media self-study program for teaching a portion of electronic solid-state fundamentals has been developed for the Air Force (Whitted and others, 1966). The media utilized in the program include programmed texts, tape-slide audiovisual presentations, a cued text, a sound movie, a workbook and an RCA transistor trainer. The effectiveness of this program was examined by comparing the results of its utilization with a conventional classroom presentation and an existing self-study unit available as an Air Force extension course. It was found that the multi-media program and the conventional classroom presentation were more effective than the extension course materials. There was no significant difference, however, between the multi-media program and the conventional presentation.

A second individualized multi-media program has been designed to stimulate polysensory learning by using as many of the student's physical senses as practical (Allen and others, 1968). The available media in this system include motion pictures, filmstrips, audio tapes, models, mockups, and worksheets to be utilized by the student at an individual student station. Three courses have been developed utilizing this approach: auto mechanics, auto body and fender repair, and a trade and technical teacher education course in individualized muti-media instruction. Preliminary findings indicate the probable effectiveness of this polysensory multi-media approach. In addition to the Allen effort, four other polysensory approaches utilizing a multi-media configuration have been identified. Nish (1968) describes the development and testing of a polysensory instructional system for teaching knowledges and skills associated with the use of expandable polystyrene plastics. The media resources available in this instructional system were single concept films, programmed instruction books, laboratory experiences and teachers' guides. The effectiveness of this approach was measured by the skill with which 30 selected students constructed a foam ice bucket. Nish found that the performance of the students exceeded the predetermined minimal standard defined as adequate, and concluded that self-instructional systems can be effectively used to teach all types of knowledges and skills. Hill (1968) applied the polysensory approach in the teaching of basic electrical occupational competencies. Media resources included a series of tape-slide sequences, workbook, and a set of laboratory exercises. Satisfactory performance on the criterion test administered at the conclusion of instruction was found. The results of an experiment in applying the polysensory approach in

the teaching of electric arc welding processes also indicate the practicability of utilizing this approach for learning even high level perceptual-motor skills and knowledge (Sergeant, 1968). Bakamis (1969) has reported on the application of the latter three approaches in an isolated school district. In discussing the implication of these polysensory approaches, he concludes that, "It is clearly becoming evident that these systems will have far-reaching implications for those not only in vocational-technical and related fields, but in all fields concerned with instruction."

Three multi-media courses have been developed for use at the Naval Academy. The three courses are physics, economics and leadership. The media resources are integrated with the total instructional system and are under the control of the computer-managed instruction component. These media are film loops, texts, slides, programmed instruction material, video tape, audio tape, and computer-assisted instruction units. Although preliminary validation studies have been conducted utilizing the material developed in the three courses, no substantial evaluative data is reported (Koontz, 1969).

Faced with the problem of training an estimated 22,000 specialists to operate a newly installed automated data processing system, the Army Logistics Management Center developed what they call a multi-media individualized instruction package (MMIIP) (Castleberry and Ketner, 1970). MMIIP consists of student guides, television tapes, programmed instruction texts, reference panels, examinations and surveys, computer-assisted simulations and an automated record keeping system. It is adapted to the learner's pace, and is portable so that it may be sent to centers where trainees are located.

Media Research with a More Limited Focus. The results of a study reported in the "Programmed Instruction" section of this review, designed to compare the effectiveness of a self-instructional booklet and laboratory demonstrations in teaching selected industrial arts manipulative operations favored neither treatment (Hofer, 1963). A second study dealing with the effectiveness of self-instructional written materials is reported by Roberson (1967). Participating in the study were 187 senior high school distributive education students. Students who were assigned to the self-instructional treatment scored no better on a criterion test of knowledge and information than a similar group of students taught by the lecture-discussion method. Conflicting evidence is found with regard to the effectiveness of self-instructional written materials in a study in which 138 junior and senior vocational agriculture students participated (McCarley, 1969). Students exposed to a self-instructional guidebook demonstrated a higher degree of knowledge and of laboratory performance at the conclusion of instruction than a similar group of students who were exposed to the lecture-discussion method.

A study by Edwards (1969) was conducted to compare the results of an audio-visual-tutorial laboratory approach with the traditional teaching method in a selected business machines course. The experimental laboratory approach included 22 continuous-loop sound films which were

reviewed by the experimental subjects in study carrels. The criterion test for the comparison was developed utilizing problems to be worked out on each of the machines studied. It was found that the experimental group scored significantly higher on the criterion test than students in the control group. Flug (1967) compared the effectiveness of film-loops and 35 mm slides in teaching a manipulative skill, and found no differences between them. He also investigated the use of an audio component versus no auditory component, and the interaction between the audio and the visual presentations. There was a significant difference in favor of the group assigned to the audio treatment. No significant interaction was noted between the audio and the visual.

In a study conducted by Amelon (1969) welding students were assigned either to a slide-tape method of self-instruction or to a group demonstration method for six selected units of the welding course. Mixed results are reported—in two units demonstration group performance scores were significantly higher; in one unit the slide-tape performance scores were significantly higher; and for the other three units there were no significant differences detected.

Bjorkquist (1965) reported efforts to examine the effectiveness of scale models and pictorial drawings in teaching orthographic projection principles. Students who utilized scale models or pictorial drawings acquired the principles with fewer trials than did students who used no visual aids. The group which received pictorial drawings was more efficient in solving a transfer task than were groups provided with scale models, receiving no visual aids, and receiving no instruction.

A study was conducted in which a group of industrial arts students were taught metal spinning by either an individualized slide-tape approach, or by an instructor demonstration method. It is reported that the self-instructional group did not attain the level of performance of the demonstration students, took more trials, and required more time to produce a spun aluminum bowl than the demonstration group (Shemick, 1965).

Summary of Research on Other Media. An interesting investigation was conducted by Stickell (1963) in which he critically examined studies comparing the effects of televised instruction versus direct instruction. Important elements of each of 250 studies were compared to the standards he proposed as adequate. Over 85 percent of the studies were classified as "uninterpretable," about 10 percent were classed as "partially interpretable," and only five percent were found to be "interpretable." Although no studies specifically comparing televised instruction and direct instruction were reviewed herein, the authors contend that it is not unlikely that an analysis of the studies reported in this section would reveal similar findings. In summarizing the media research precautions were thus taken to avoid overstatements. The purpose of including the variety of media research reported was to expose the reader to a reasonable variety of research currently being conducted in the field with relevance for vocational and technical education. The most restrictive element with regard to the selection of media studies was that which related to the

criterion that they be focused on an individualized concept of instruction. Some evidence was uncovered to justify further application of multi-media approaches to vocational and technical education. Additional evaluative data is needed, however, in order to be able to firmly establish the effectiveness of the multi-media concept. Continued efforts by those responsible for the Naval Academy program, the 'polysensory" system, and the MMIIP approach could provide substantial evidence within the near future to allow tentative evaluative judgments to be made.

Of the eight studies in this section which were designed to investigate the effects of a particular type of instructional medium six were evaluative in nature. Of these six investigations: three found no differences between the experimental treatment and a "conventional" approach; two found differences favoring the experimental media approach; and one found mixed results for six units of welding. Such conflicting evidence among the studies reviewed provide substantial support for the notion that in order for an investigation to provide its maximum contribution it must be conceptualized as part of a programmatic research effort. The alternative is to be faced with the situation that has resulted here—that questionable feedback results.

INSTRUCTIONAL STRATEGIES

Instruction has been described previously as the means by which educational goals as determined by the curriculum are accomplished (MacDonald and Leeper, 1965). Instructional strategies, therefore, may be generally viewed as the alternative paths designed to achieve a specified set of instructional objectives. The research reported in this section primarily focuses upon uncovering the effectiveness of alternative individualized instructional strategies in the learner's attaining those objectives. Programmed instruction, CAI, CMI, and other instructional system approaches may be considered macro-instructional strategies. Since they have been reviewed in separate sections of this document, no reference will be made to them here. This discussion is limited to research dealing with learning variables related to individualized instruction such as pacing, prompting, feedback, control in error rate, degree of redundancy in material, varieties of brancing, etc. It involves what might be called the microlevel of instructional designing. Studies have been selected for inclusion on the basis of their implications for vocational and technical education.

Pacing

Studies are reported herein which examine the rate at which instruction proceeds, that rate being determined either by the student at his own pace, regulated by an automated device, or fixed by some external source.

Fixed-Paced versus Self-Paced Instruction. Heyel (1967) reports the results of an experiment to compare a self-paced instructional unit with a fixed-paced unit covering the same material. The unit was an eighth grade industrial arts programmed sequence designed to teach youngsters to prepare and lock-up a single type form. Written and performance tests were administered at the conclusion of instruction after two and six weeks. It was found that the group of eighth grade boys assigned to the fixed-paced treatment performed no differently on the criterion measures than the group of eighth grade boys assigned to the self-paced treatment. It was also found that boys in each of the two groups performed significantly better on the criterion measures than a third group who received no instruction but took the criterion tests. Another comparison between self-paced and fixed-paced instruction is reported by West (1968). Two hundred and forty high school students at four levels of typewriting skill were assigned to either a self-paced or a fixed-paced unit designed to increase speed and accuracy in accomplishing ordinary typewriter copywork. He found that neither speed nor number of errors differed between the two groups when the criterion test was administered immediately prior to the instructional treatment. The results of two additional experiments comparing the effects of self-paced versus fixed-paced also confirm the lack of a significant difference in performance results (Anderson and others, 1955; Nystrom and others, 1955). The criterion measure in each of these experiments was a self-paced psychomotor performance task.

Other Pacing Studies. In a study designed to compare the effects of

a self-paced instructional unit with a traditional lecture-demonstration unit to teach accepted safety practices in operating woodworking machines, it was found that the former resulted in a significantly higher performance for a sample of undergraduate males in industrial education (Beckham, 1969). The criterion measure involved a composite rating by three judges who viewed a video tape of each student's operation of the equipment immediately following the instructional treatment. Another significant finding was the saving of instructor's time during the self-paced program so that he could be free to work with individual students. Bushnell (1963) also compared the effect of self-paced instruction with conventional instruction. The task was to teach selected introductory concepts in industrial electronics to a group of 96 journeymen electricians. Their performance at the conclusion of instruction and their satisfaction with the course to which they had been assigned were the criterion variables. The electricians were assigned to one of three instructional treatments: a self-paced individualized instruction unit with branching; the same self-paced unit with an opportunity to discuss problems and issues that may have been raised during the instructional experience with a qualified instructor; and a conventional classroom arrangement. No significant differences between the three groups in their criterion performance were reported, although the group assigned to the self-paced unit with an opportunity to discuss questions with the instuctor was more highly satisfied with the experience (Bushnell, 1963).

Two methods of fixed-paced instruction were investigated by Kress and Gropper (1965). A fixed-paced unit with prompting (providing the correct answer for the student) was compared to differential fixed-pacing for homogeneous groups. The students who were placed in the homogeneous groups performed significantly better than the students who received prompting.

Studies Examining Other Learning Variables

The number of studies identified by the authors which systematically examine learning variables, and at the same time have direct implication for vocational and technical education was quite small. The rather crude grouping of these studies as presented in this section was therefore necessitated by the limited range of the field that is covered by those studies.

Prompting as Compared to Confirmation. Engelbart and Sorensen (1965) compared the effects upon learning of a variety of prompting conditions and confirmation conditions. The task was to train subjects to operate a five-key chord keyset for transmitting letters and numerals. Three prompting conditions (automated visual, automated tactile, and non-automated), a confirmation condition, and a no-confirmation condition were designed. It was found that confirmation utilized in a selected training program resulted in a significantly higher criteria performance than any of the prompting treatments. It was also found that visual prompts resulted in better performance than tactile prompts in both speed and accuracy. Two additional studies support this finding. The first investiga-

tion was an attempt to measure the effectiveness of selected instructional treatments in training subjects to use a symbolic coding language and the basics of computer programming (Seidel, 1968). Competency of the subjects was measured at the conclusion of instruction and four weeks later. Three independent experiments were conducted dealing with the comparison of the prompting condition and the confirmation condition. In each of the experiments the confirmation of responses led to significantly higher performance than the prompting treatment. Csanyi, Glaser and Reynolds (1964) conducted a study which resulted in a similar finding. The authors did identify one study in which the differences between prompting and confirmation were found to be nonsignificant (Weisz and McElroy, 1964). It is inferred that the difference between their results and previous findings may be due to the nature of the tasks to be performed, and the procedures which they employed.

Scanlon and Tom (1967) conducted an investigation in which they randomly assigned a group of ninth grade first-year vocational agriculture students to one of three instructional conditions. These treatments were: a programmed unit, the unit plus blocked review, and the unit plus spaced review. The students were tested for amount learned at the conclusion of instruction and 30 days later. Although the treatment providing blocked review proved better than the treatment with spaced review, neither of the review conditions led to significantly greater learning than the programmed instruction unit itself. No differences were found between any of the treatments on the test for retention.

Sprenger (1970) investigated the effects of block size and the use of mnemonic aids in learning the basic Gregg shorthand alphabet. He assigned 100 secondary school students to one of five block size conditions and to either a mnemonic aid treatment or to a non-mnemonic aid treatment. It was found that those students receiving mnemonic aids required fewer trials to reach criterion immediately following instruction than those students who had not received those aids. That difference was not found in the retention test given 48 hours after the instruction. No significant effects were attributable to block size. A study related to the previous report was conducted by Briggs, Naylor and Fuchs (1962). It was designed to investigate pure-part, progressive-part, simplified and whole training techniques and their effectiveness in teaching a three-dimensional tracking task. It was found that in the simpler tasks the whole method was superior. Some evidence was revealed, however, indicating that the more complex the task to be learned, the higher the relative efficiency of the progressive-part method.

Five versions of an individualized program on medical terminology were evaluated by Valverde and Morgan (1969), to determine the effect of redundancy on learning. The 440 subjects involved in the experiment were randomly assigned to one of five groups: 1) a 274 frame linear program, 2) a 160 frame linear program, 3) an 83 frame linear program, 4) a narrative test, and 5) 4-inch by 6-inch summary cards. Subjects in treatment groups 1 and 2 scored significantly lower on the criterion tests

than those in groups 3, 4, and 5. There were no differences between groups 1 and 2 and between groups 3, 4, and 5. The investigators conclude that the repetition included in the longer programs (Groups 1 and 2) may detract from the effectiveness of self-instructional programs. Conflicting findings were reported by Dawson (1969) regarding the relationship between redundancy and effectiveness. Dawson, in comparing the effectiveness of a high redundancy and a low redundancy program found that students exposed to the former treatment scored significantly higher than those students exposed to the latter treatment.

Seidel (1968), in addition to comparing the prompting condition and the confirmation condition as reported previously, examined the effects of verbalization and the effects of variety of practice on performance. The three verbalization treatments were: subjects in the first group were required to write in the entire rule applicable to the problem; students in the second group were required only to write a mnemonic; and students in the third group were required to write nothing. The two practice treatments were a variety treatment and a repetitive treatment. Measured by the criterion test to determine the degree to which students had acquired ability in solving computer programming problems, the group required to write a mnemonic for the rule scored significantly higher than the group who were required to write nothing, both of which scored significantly higher than the group who were required to write the entire rule applicable to the problem. It was also found that those students who were exposed to a variety of practice exercises scored significantly higher on the criterion measure immediately after the conclusion of instruction than those students who were exposed to repetitive practice exercises. Retention tests given at the end of four weeks revealed the same results.

Briggs (1962) conducted an experiment to determine the effect of negative feedback as compared to positive feedback in the acquisition and transfer of skill. He found that feedback given when the subject was in error resulted in significantly higher levels of performance than when feedback was used to indicate that the subject was performing acceptably.

Landecker (1969) conducted a study in which two groups taught by a conventional method were compared with the performance of two groups exposed to delayed-response learning guides. The unit was selected from the field of mechanics. It was found that the mean score on a mechanics achievement test immediately following instruction was significantly higher for the two delayed-response groups than it was for the two conventionally taught groups. There were no significant differences between the attitudes of the students taught by the different methods.

Mirabella and Lamb (1966) investigated several aspects of an adaptive training approach developed for use by the Navy. They report the results of adaptive versus nonadaptive training upon performance in a visual target detection task. It was found that increasing the complexity of the display material during the course of training, and at the same time requiring subjects to actively respond to the material, was a more effective approach than maintaining a constant level of display complexity, and at

the same time requiring only passive viewing of the displays. It was also found that a high error rate during the course of instruction was not necessarily detrimental to performance after training. Kelley (1969) and Matheny (1969) also discuss various aspects of adaptive training. Kelley, in an article entitled "What is Adaptive Training?" defines it as "training in which the problem, the stimulus, or the task is varied as a function of how well the trainee performs." "The basic requirement for adaptive training systems is the need for automatically changing training task difficulty" (Matheny, 1969). During the course of instruction in the adaptive training approach the material presented to a student at a particular time is adjusted automatically to conform to the measured level of the student's skill.

Summary

In examining the effects on student performance of several learning variables such as manner of pacing, varieties of confirmation and prompting, type of review condition, block size, degree of redundancy, and feedback the studies reported in this section revealed a number of consistent results.

1. Those studies comparing self-paced and fixed-paced instructional units found no differences in their effect upon students' criterion performance.
2. The confirmation condition resulted in significantly higher student criterion performance when compared with several prompting conditions.
3. Significant differences in students' criterion performance between treatments found immediately after instruction tended to dissolve when students were tested for retention.

Conflicting results were found in attempting to summarize the effects on students' criterion performance of: self-paced instructional units compared with conventional instruction; varying degrees of redundancy in instructional materials; and blocked review as compared with spaced review.

The only attempts reviewed to systematically investigate the effects of varying instructional strategies were found in the programmatic research contracted for the military. It is likely that such research efforts will have a significant impact upon research in vocational and technical education in the near future.

INSTRUCTIONAL SYSTEMS APPROACHES

An instructional system may be defined as "an integrated set of media, equipment, methods, and personnel performing efficiently the functions required to accomplish one or more . . . objectives" (Smith, 1966). It may be argued that our current educational and training programs have been developed on a systematic basis. Each person or group responsible for developing an educational or training program must operate by some system or other (Odiorne, 1965). Instruction in this sense is and always has been systematic (Bern, *et al.*, 1965). What, then, distinguishes instructional systems from those systematic efforts to develop instructional programs in vocational and technical education for the past 60 years? Lehmann (1968) describes eight steps in the development of an instructional system. These are:

1. Need—the education/training problem;
2. Objectives—measurable learning goals;
3. Constraints—restrictions or limitations;
4. Alternatives—candidate's solutions;
5. Selection—choice of best alternative;
6. Implementation—pilot operation of the chosen solution;
7. Evaluation—measurement of results obtained against originally stated objectives; and
8. Modification—the change of the system to current for the deficiencies noted.

Lehmann's list of steps in the design of instructional systems is quite similar to that proposed by Smith (1966):

1. Preparing the training objectives,
2. Sequencing the objectives of the system,
3. Identifying required functions,
4. Selecting components and procedures,
5. Analyzing cost-effectiveness,
6. Coordinating components and procedures, and
7. Evaluating the system.

The steps listed by Smith do not include the identification of the education/training problem nor the modification of the instructional system. Smith takes these into consideration, however, in his presentation of an instructional system model. This model includes the job as a starting point for the training problem, and incorporates the evaluation of the system into its redesign. He views systems as developmental and changing, and perceives the function of evaluation as an aid in the continuous modification of the instructional system. Smith's step number 5, the analyzing of the cost-effectiveness of the system, need not be viewed as an integral part of the instructional design. It is, of course, an important consideration for those responsible for operating training or educational programs.

The systems approach to instruction employs a systematic structuring of curriculum material from the learner's point of view, resulting in a

logical, functional, step-by-step path whereby the learner proceeds from his personal starting level through accomplishment of previously set performance objectives (Lehmann, 1968). McFann (1969) describes the implication of this process in terms of interrelationships between ability levels, type and complexity of content, organization and sequencing, material, method and media of instruction, motivation, and management.

One set of specifications for instructional systems which focuses on these interrelationships and accounts for the evaluation and modification of the system has been proposed (Ikenberry, 1970):

1. The instructional system shall be independent of time restrictions in the sense that individuals shall be able to progress at their own rates, shall be able to begin the learning sequence when it seems educationally desirable and shall be able to continue the instructional process until mastery has been achieved.
2. The objectives of instruction shall be relevant to the immediate and long-term needs of the learner, and the learner shall be cognizant of this relevance.
3. Educational objectives shall be stated in unambiguous terms which make clear the intellectual competencies to be developed by the learner.
4. The instructional system shall maximize student active involvement in the learning process.
5. The instructional system shall provide accurate, timely and formative feedback to the learner regarding his progress toward learning goals.
6. The instructional system shall be designed to maximize the principles of positive reinforcement and eliminate or minimize those aspects known or suspected to be aversive to the learner.
7. The instructional system shall insure appropriate sequencing of learning experiences, shall be capable of diagnosis of learner deficiencies and adjust the instructional sequence appropriately.
8. The instructional system shall solicit reliable and timely information on individual student learning progress and shall make adaptations appropriate to the individual learner.
9. In the development of instructional goals and processes, the instructional system shall take into account the total environment in which the student learns.
10. The instructional system shall have a recognizable "style", a cognitive structure sufficiently obvious to provide a basis for student choice among institutions, to provide meaning or relevance to learning, and to encourage continuous commitment to learning throughout life.

Two general types of instructional systems with relevance to vocational and technical education were identified. Learner-centered instruction (LCI) has been developed by personnel from the Air Force Human Resources Laboratory. The second general type of approach has been

under development in a number of locations throughout the country and may be referred to generally as computer-managed instruction (CMI).

Learner-Centered Instruction

LCI is an instructional system designed by the Air Training Command in which a student is assigned behavioral objectives and proceeds at his own rate, with minimum assistance from an instructor, until he can perform those objectives (Bumstead, 1969; Valverde, 1969). The first course to be developed as part of the LCI system was an electronics course appropriate for airmen preparing for specific duties as mechanics or technicians working on a particular weapons system. The course included the use of several instructional media and devices, programmed books, teaching machines, and task simulators (Pieper, Folley, and Valverde, 1969b). A special job performance test was developed as a criterion measure in evaluating the success of the LCI course. It was based upon tasks derived from the behavioral description of the actual job, and contained three parts: 1) operational checkout, 2) troubleshooting, and 3) auxiliary task performance (Pieper, Folley, and Valverde, 1969a). The effectiveness of this LCI course as compared to the conventional Air Force course to train a similar type worker was explored. Those completing their respective courses were compared with regard to their job performance immediately following completion, job performance after five months, student acceptability, and instructor reactions. It was reported (Peiper, Swezey, and Valverde, 1970) that the performance for the LCI group was significantly greater than for the conventional group, that the cost of the LCI course was substantially lower than that of the conventional course, and that the courses were equally acceptable to the trainees.

Computer-Managed Instruction (CMI)

According to Baker (1971) the outgrowth of the computer-managed instructional system development was due to the effort of a number of researchers to systematically individualize instruction without involving CAI. It becomes immediately clear to attempting to individualize an instructional program that the most crucial problem is one of management. The major functions of a CMI system are those of scoring seat work, scoring test papers, recording scores, creating descriptions of pupils based on their scores, and keeping track of the instructional materials a particular student has used. Given these mechanical tasks, it is the larger goal to provide the teacher with the tools of management (Baker, 1971). The distinction between CMI and CAI is the focus of the former on instructional functions and of the latter on the management of instruction (Baker, 1971; Koontz, 1970). Viewed in this manner, programmed CAI units may be considered to be part of the CMI system. The Naval Academy project as described below does, in fact, involve the use of the CAI units as one of several instructional procedures integrated within a computer-managed instructional system. Baker (1971) in reviewing several computer-managed instructional systems indicates their four major functions: test scoring,

diagnosing, prescribing, and reporting. Five examples of CMI systems were identified by these reviewers which have some relevance to vocational and technical education. These are: 1) the Naval Academy project as mentioned previously; 2) the Memphis Naval Air Technical Training Project; 3) Project PLAN (Program for Learning in Accordance with Needs) developed at the American Institutes for Research; 4) IPI (Individually Prescribed Instruction) developed at the University of Pittsburgh, Center for the Study of Learning; and 5) Project ULTRA (Unlimited Training for All), developed at the New York Institute of Technology.

The development of a CMI system at the Naval Academy emerged from the necessity to systematize the management function in utilizing CAI equipment and a multi-media course development effort. As indicated previously by Baker (1971) the problem of managing instruction is broader than the instructional problems faced in CAI. Koontz (1970) describes the Naval Academy CMI effort as it relates to the development and field testing of a number of technical-type courses. The computer functions identified in this system are: data acquisition, data interpretation (scoring of multiple-choice tests and item analyses), prescription, scheduling, and validation/evaluation.

A CMI system developed at the Memphis Naval Air Technical Training Center is aimed at reducing training costs (Johnson, 1967). The rationale in developing this training system was the selection of one or two alternatives in individualizing instruction. One may either hold time for training constant and allow quality to vary, or hold quality constant and let the training time vary. Since the latter was selected as one of the constraints on this CMI system, the objective was to reduce training time as much as possible while holding to a constant minimal quality level. The CMI system as developed resulted in reduced training time by: 1) alternating paths through instruction; 2) eliminating unnecessary instruction; 3) avoiding repetition of what some students already know by pretesting; and 4) having the students take greater advantage of self-instructional materials.

Project PLAN was developed by the American Institutes for Research as a means of correcting deficiencies in our educational system as identified by their Project TALENT efforts. PLAN consists of five components (Flanagan, 1968):

1. A comprehensive set of educational objectives grouped into modules.
2. Teacher-learning units which prescribe materials to be used by students in obtaining these objectives.
3. Evaluation procedures whereby post-testing at the completion of a module and the measurement of long-term objective achievement is determined.
4. Guidance and individual planning materials.
5. A medium-sized computer to perform the mechanical tasks of test scoring, maintenance of file, recording student results on the

> teacher-learning units and keeping track of the student's progress in his guidance and planning procedures.

The relevance of the PLAN approach to vocational and technical education is viewed more readily in the context of the Project ABLE effort. The approach to the individualization of instruction utilized in Project ABLE, also conducted by the American Institutes for Research (Ullery and Micastro, 1970), is taken from the same computer-managed base as the PLAN approach. Primarily envisioned as a curriculum effort in vocational technical education, Project ABLE incorporates an instructional strategy involving an instructional management system with all the features as described in the PLAN system.

The Individually Prescribed Instruction (IPI) project at the University of Pittsburgh incorporates a CMI system as part of its approach. As described in a recent progress report (Research for Better Schools, 1969), IPI includes: placement testing and prescription technology, pretesting, instructional materials built around specified objectives, periodic progress reports of an individual's progress, a post-test to measure overall mastery, and a management system for teachers. IPI is being tried out initially at the Oak Leaf Elementary School in the Baldwin-Whitehall School District of Pennsylvania.

> A computer-management system is being developed at Oak Leaf School to help research and implement individualized instruction. Its purpose: matching relevant measures of student performance with appropriate curriculum methods and materials to assist teachers in preparing instructional prescriptions for each student (National School Public Relations Association, 1968).

Project ULTRA developed by the New York Institute for Technology is designed for the training of engineering technicians. It involves: diagnosis, progress checks, prescription, and overall evaluation (Schure, 1965). As part of its diagnostic feature this CMI approach incorporates the results of an occupational inventory, giving additional guidance information.

Baker (1971) in his summary of various CMI projects concludes:

> As is the case with CAI, the promise of CBIM (Computer-based instructional management) systems far exceeds the present accomplishments. The present systems are rudimentary, provide the teacher precious little management assistance and are available on a very limited basis. Primary attention has been given to getting such systems up and running, and their role as a management tool for the teacher has been nearly ignored. Hopefully, now that the feasibility of CBIMS has been demonstrated, attention can turn to the reason for their existence.

Based on his contact with the Naval Academy project, Koontz (1970) reaches a similar conclusion.

Other Instructional Systems Applications

Detroit Northern Systems Company has developed a training system approach for the hard-core unemployed. The system is described by which training objectives are achieved "through an interplay of program components which include training lines of tool stations, back-up classes which precede the tool line, remedial classes. . . ., and the Social Skills Seminar . . ." (Harrison, 1970). Instructional systems design with implications for industrial and technical education was the focus of a recent article appearing in the *Journal of Industrial Teacher Education* (Frantz, 1970). Implications for industrial and technical education at the elementary, secondary, and post-secondary levels were presented as a significant outgrowth of the instructional systems approach.

As a result of numerous instructional systems development efforts throughout this country several types of instructional packages have been produced as components. For examples of such use in experimental programs see Esbensen (1968) and Edling (n.d.). A study was conducted in 1965 to measure the effectiveness of a mathematics package for the occupational training of depressed area students. It was reported that students in the group exposed to the mathematics package scored significantly higher on the criterion test immediately upon completion than a similar group exposed to the conventional treatment (Bushnell, 1966). A a result of the study it was recommended that an additional five semester units of instruction in subject areas essential to vocational education programs be produced and validated.

Summary of Instructional Systems Development

Several instructional systems development efforts which may potentially be applied to vocational and technical education were identified. These efforts are in varying stages of development, the most advanced of which appears to be in the learner-centered instruction approach. Available evaluative data describing outcomes of field trials utilizing LCI materials suggest its desirability in terms of effectiveness, cost, and acceptance by students and instructors. Essential components of the LCI system include the specification of job tasks as initial instructional objectives, and the measurement of job performance as an evaluative criterion. In terms of the instructional objectives and evaluative criteria typically desired of vocational education programs, the LCI approach would need only slight modification to be applied to selected vocational and technical areas.

Some may argue that instructional systems evolving from an education base are more appropriate for applying to vocational and technical areas than LCI which has a military training base. Given the encouraging results of preliminary trials of LCI it is argued here that no systems approach in education has demonstrated such results. As Loughary (1968) points out, "although the instructional systems approach has a great potential to improve education, its current efforts are sporadic, uncoordinated, and lack research support."

The design of instructional systems is not an easy task, nor does it guarantee learning. It is not an easy task because it's a task that never is completed. It's a continuously evolving, dynamic process of development, evaluation, and redesign (Koontz, 1970c). Its potential for vocational and technical education is so appealing, however, that the time, effort, and scientific precision involved in its design is a small cost to pay based on its potential payoff.

70

SUMMARY AND RECOMMENDATIONS

Based upon the framework for individualized instruction in vocational and technical education described in the first two sections of this document, and upon the nature of the research and developmental activity reported in the following sections, certain relevant observations have been made by the authors. These observations provide the focus for the first phase of this final section—the "state of the art" of research and development having effect upon individualizing instruction in vocational and technical education. No attempt is made to provide syntheses of individual foci within the field, since specific summaries are presented at the conclusion of each major section of this document. Within this final portion emphasis is placed upon the integration of the specific summaries.

Given the current status of the field, the authors offer a list of recommended research and development activities necessary to move toward fulfilling the potential of individualized instruction for improvement of vocational and technical programs. The twofold intent of this section is designed to draw out implications for both researchers and practitioners in vocational and technical education.

Synthesis of Individualized Instruction Research

Observation 1. A number of investigations reviewed in this document demonstrated that certain approaches to individualizing instruction were effective in facilitating selected learning outcomes for specific groups of students under particular conditions.

Observation 2. Both the quantity and quality of research examining the individualization of instruction in vocational and technical education have increased considerably each year since 1965, at which time the first significant research efforts of this type were undertaken.

Observation 3. An increasing cognizance of relevant factors influencing the design of individualized instruction is demonstrated in the most recent research and development efforts in vocational and technical education.

Observation 4. Much of the military training research reviewed in this document exemplified the type of programmatic research and development activity necessary to resolve in a systematic fashion the multitude of problems emanating from the individualized approach to instruction.

Observation 5. The most promising area of individualized instruction research and development in terms of its potential contribution to the improvement of vocational and technical instruction is represented by the instructional systems approach. Because of its global nature the instructional process conceived as a system must take into account the effect of its essential components and their interactions, including cost contraints, nature of instructional objectives, evaluative design, and criteria for modification. The shortcomings of many of the studies reviewed in this document, as related in the following observations, are the results of a restricted conception of the instructional process—an unlikely occurrence in utilizing the systems approach.

Observation 6. The samples utilized in much of the research reviewed in this document were not composed of the type of student to which we desire to generalize the results. Given that the primary purpose of individualizing instruction is to meet the educational or training needs of the whole spectrum of our student population, little effort appears to have been made to adequately represent that range.

Observation 7. The emphasis upon the development of actual work performance skills in vocational and technical programs has not been sufficiently recognized in most of the research reviewed. The preponderance of studies posed rather artificial, easily measured criterion variables upon which to measure instructional effectiveness.

Observation 8. An overabundance of studies dealt with the differential effectiveness of one or more experimental treatments and a convention or traditional instructional method. In spite of the considerable criticism leveled upon such research (Bloom and others, 1971; Briggs, 1968; Reid and others, 1967; Sullivan, 1969; and Travers, 1962), and its failure to provide meaningful and interpretable results, it still seems to persist.

Observation 9. Because of the extreme importance of individual student differences to the design of individualized instruction, the authors chose to report in a separate section studies which accounted for selected student characteristics in some way. Several studies of this type were identified, most of which accounted for aptitude differences, but avoided affective differences (such as attitudes, motivation, interests, or values).

Observation 10. The research reviewed was generally simplistic in design, avoiding the examination of interactive effects such as instructional treatment by type of objective, or instructional treatment by level of student ability. Doctoral studies particularly demonstrated this tendency toward the univariate approach.

Observation 11. The only significant attempts to replicate research were found in studies conducted for the military. The lack of replication is at lease partially due to the failure of most studies to adequately describe the instructional treatments being tested.

The great variety of research and developmental activities identified by the authors as relevant for inclusion in this review is strong evidence that individualized instruction is perceived to have a great potential for improving vocational and technical education. Other circumstances leading to an optimistic view of the future are the relatively short period of time during which the systematic study of individualized instruction has been going on, and the short history of research in vocational and technical education.

Although several studies have been reported in previous sections of this document which support the effectiveness and feasibility of individualized instruction when utilized in vocational and technical programs, the tangible accomplishments of research and development activity in this field are extremely difficult to identify and describe explicity. Their contribution appears to be as precursors of things to come rather than as hard, established gains. With a goodly supply of trained professionals

working on the design of individualized instruction approaches, and ample evidence as to its potential in improving vocational and technical education, the future appears bright.

Recommendations for Research and Development

1. Programmatic research and development efforts are needed to improve the current status of individualized instruction in vocational and technical education. Teams of researchers, curriculum specialists, instructional technology specialists and teachers must be formed to embark upon research and development efforts geared specifically to vocational and technical education. Viewed as a total system, instruction can be effectively designed only by the cooperative efforts of practitioners and researchers. The task is too complex and the system is too dynamic for implementation to be set apart from research. Householder (1968) calls for a concerted effort toward problem areas like individualized instruction which are of widespread concern, and Taylor and Christensen (1967) urge a profession-wide research and development program to assess the optimal applications of media to vocational and technical education. Global attempts such as these are essential in moving toward realization of the potential individualizing instruction has in our field.

2. Related to the necessity for wide-scale attacks upon research and implementation problems is the necessity to acknowledge and utilize selected ideas and devices initially developed for military use. The considerable overlap between vocational and technical education and military technical training suggests that the large amount of research and development activity conducted for the military may hold substantial transferability to civilian counterparts (Briggs, 1967). Some success has already been noted in isolated attempts to accomplish this transferral (Straubel, 1971).

3. The increasing number of doctoral theses being produced provides vocational and technical education with a potent resource in launching a large-scale research and development effort. We cannot afford to disregard the potential contributions of these young scholars if a serious attempt is to be made in designing effective instructional packages for use in vocational and technical education. However, these doctoral students can become part of the team only through the stimulation of university faculty who are members themselves. One doctoral study which evolves from a programmatic research and development effort, and becomes a significant part of that effort, contributes an infinitely greater amount to the field than a study conceived and conducted in isolation.

4. Research focusing upon selected aspects of individualizing instruction is essential in the improvement of vocational and technical education. Based upon research of that type reviewed in this document, the authors contend that certain qualities of future research efforts need to be emphasized.

a. In the formulation of instructional objectives and the means designed to measure them, emphasis should be placed upon work performance criteria.
b. Interactive effects of instructional treatment with other factors, particularly student affective characteristics, need to be examined.
c. Samples utilized in studies exploring the effects of individualized instruction must be drawn from the population to which the results will be generalizable.
d. In order to provide for the possibility of replicating an experimental study, a thorough description of the instructional treatments examined must be presented.
e. Experimental research replicating prior studies is a scholarly activity, and is highly desirable.

BIBLIOGRAPHY [1]

(Boldface numbers indicate pages which cite the references)

Aiguirre, Edward. *An Experimental Study of Two Methods of Teaching Engine Lathe Principles and Procedures.* Doctoral Thesis, Arizona State University, 1966. 171 pp. Microfilm No. 66–902. **32**

Allen, David, *et al. Polysensory Learning Through Multi-Media Instruction in Trade and Technical Education.* Los Angeles, California: Division of Vocational Education, University of California, 1968. 68 pp. (ED 022 458 MF $0.65 HC $3.29) **49**

Allen, William H. *Trends in Instructional Technology.* Stanford, California: ERIC Clearinghouse on Educational Media and Technology, 1970. 32 pp. (ED 043 242 MF $0.65 HC $3.29)

Amelon, Donald J. *Slide-tape Self-instruction Versus Traditional Group Demonstrations in Teaching College Level Metalwork.* Doctoral Thesis. Columbia, Missouri: University of Missouri, 1969. 330 pp. Microfilm No. 70–7905. **51**

Anderson, Norman H.; Kresse, Frederick H.; and Grant, David A. "Effect of Rate of Automatically-Paced Training in a Multidimensional Psychomotor Task." *Journal of Experimental Psychology.* 49: 231–236, April, 1955. **53**

Armstrong, William H. *An Experimental Investigation of the Instructional Effectiveness of Published Programmed Instruction Materials vs. Individualized Instruction in Area Vocational-Technical Schools.* Doctoral Thesis. Tallahassee, Florida: The Florida State University, 1967. 141 pp. Microfilm No. 67–11, 149. **26**

Ashmun, Richard D. *The Effectiveness of a Non-Computer Business Game in Teaching Post-High School Business Problems Classes.* Doctoral Thesis. Minneapolis, Minnesota: University of Minnesota, 1966. 196 pp. Microfilm No. 67–850. **46**

Association for Supervision and Curriculum Development. *Criteria for Theories of Instruction.* Washington, D.C.: Association for Supervision and Curriculum Development of the National Education Association, 1968. 54 pp. (ED 030 607 MF $0.65 HC $3.29) **6, 7**

Atkinson, Carrol, and Maleska, Eugene T. *The Story of Education.* New York, N.Y.: Chilton Company, 1962. **4**

---

[1] Bibliographical entries followed by an ED or MP number in parenthesis are generally available in hard copy or microfiche through the Educational Resources Information Center (ERIC). This availability is indicated by the abbreviations, MF for microfiche and HC for hard copy. Order from ERIC Document Reproduction Service (EDRS), P. O. Drawer O, Bethesda, Maryland 20014. Payment must accompany orders totaling less than $10.00. Doctoral dissertations with a microfilm number are available in microfilm ($4.00) or xerographic copy ($10.00) from University Microfilms, Dissertation Copies, Post Office Box 1764, Ann Arbor, Michigan 48106. Biographical entries followed by an AD or PB number in parenthesis are generally available in microfiche or paper copy through the National Technical Information Service (NTIS), Springfield, Virginia 22151. Microfiche price is $0.95 per title and paper copy price varies with the length of the report. All orders must be accompanied by a check or money order.

Bakamis, William A. "A Multimedia Model for Total Selfinstructional Systems." *School Shop*. 29: 54–57, November, 1969. **50**

Baker, Frank B. "Computer-Based Instructional Management Systems: A First Look." *Review of Educational Research*. 41: 51–70, February, 1971. **61, 62, 63**

Baldwin, Thomas S. "Evaluation of Learning in Industrial Education." *Handbook on Formative and Summative Evaluation of Student Learning*. Bloom, B. S.; Hastings, J. T.; and Madaus, G. F. New York, N.Y.: McGraw-Hill, 1971. **13, 18**

Ballard, John R. *A Study to Determine the Effectiveness of Two Methods of Instruction or Achievement and Retention in Industrial Arts*. Doctoral Thesis. College Station, Texas: Texas A and M University, 1966. 202 pp. Microfilm No. 67–4693. **32**

Beckham, Joe W. *An Experimental Comparison of Self-paced Instructional Materials Versus the Traditional Method in Teaching Woodshop Safety*. Doctoral Thesis. Commerce, Texas: East Texas State University, 1969. 138 pp. Microfilm No. 69–21, 163. **54**

Bennett, Charles A. *History of Manual and Industrial Education, 1870–1917*. Peoria, Illinois: Chas. A. Bennett Co., 1926. 1 p. **3**

Bensen, M. James. *An Investigation in the Use of Programed Operation Sheets as a Supplement to the Group Demonstration in Teaching Manipulative Operations. Doctoral* Thesis. University Park, Pennsylvania: The Pennsylvania State University, 1967. 187 pp. Microfilm No. 68–11967. **35, 38**

Bern, H. A., *et al.* "Reply to Questions About Systems." *Audiovisual Instruction*. 10: 366–370, May, 1965. **59**

Biel, William C. "Training Programs and Devices." *Psychological Principles in System Development*. Edited by Robert M. Gagne. New York, N.Y.: Holt, Rinehart and Winston, 1962. **48**

Bishop, Lloyd K. *Individualizing Educational Systems*. New York, N.Y.: Harper and Row, 1971. **6**

Bjorkquist, David C. "The Relative Effectiveness of Scale Models and Pictorial Drawing in Learning Orthographic Projection." *Journal of Industrial Teacher Education*. 3: 11–18, Spring, 1965. **51**

Bloom, Benjamin S. "Learning for Mastery." *Evaluation Comment*. May, 1968. **17, 43**

Bloom, Benjamin S., ed. *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook 1. Cognitive Domain*. New York, N.Y.: McKay, 1956. **11**

Bloom, Benjamin S.; Hastings, J. Thomas; and Madaus, George F. *Handbook on Formative and Summative Evaluation of Student Learning*. New York, N.Y.: McGraw-Hill, 1971. 923 pp. **16, 17, 18, 19, 68**

Briggs, George E. *On the Scheduling of Training Conditions for the Acquisition and Transfer of Perceptual-Motor Skills*. Technical Report NAVTRADEVCEN 836–1, December, 1961. **27**

_____. *Research on Augmented Feedback and the Acquisition and Transfer of Skill*. Technical Report NAVTRADEVCEN 836–3. Port Washington, N.Y.: U.S. Naval Training Device Center, September, 1962. 49 pp. **56**

Briggs, George E.; Naylor, James C.; and Fuchs, Alfred H. *Whole Versus Part Training as a Function of Task Dimensions*. Technical Report

NAVTRADEVCEN 950–2. Port Washington, N.Y.: U.S. Naval Training Device Center, February, 1962. 52 pp. **55**

Briggs, Leslie J. "Learning Theory, Media of Instruction, and Vocational Education." *Educational Media in Vocational and Technical Education. Leadership Series No. 14.* Edited by Calvin J. Cotrell and Edward F. Hauk. Columbus, Ohio: The Center for Vocational and Technical Education, The Ohio State University, 1967. 255 pp. (ED 017 730 MF $0.65 HC $9.87) **69**

_____. *Sequencing of Instruction in Relation to Hierarchies of Competence.* Monograph No. 3. Pittsburgh, Pennsylvania: American Institutes for Research in Behavioral Sciences, April, 1968. 106 pp. (ED 018 975 MF $0.65 HC $6.58) **68**

_____. *Handbook of Procedures for the Design of Instruction.* Monograph No. 4. Pittsburgh, Pennsylvania: American Institutes for Research, September, 1970. 206 pp. (ED 043 230 Document not available from EDRS) **6, 11, 14, 19**

Bruner, Jerome, ed. *Learning About Learning. A Conference Report.* Washington, D.C.: Office of Education, U.S. Department of Health, Education and Welfare, 1966. 280 pp. (ED 015 492 MF $0.65 HC $9.87) **6**

Bumstead, Richard. "Individualized Instruction." *Educate.* Vol. 2, No. 1, January, 1969. **61**

Bush, Wilma Jo, *et al. Some Interactions Between Individual Differences and Modes of Instruction.* AMRL Technical Report 65–228, December, 1965. (AD 631 138) **25**

Bushnell, David S. *Technological Change and The Journeyman Electrician, an Experimental Study in Continuing Education. Volume I.* Menlo Park, California: Stanford Research Institute, March, 1963. 131 pp. (ED 017 671 MF $0.65 HC $6.58) **54**

Bushnell, Don D. *The Production and Validation of Educational Systems Packages for Occupational Training of Depressed Area Students. Final Report.* Santa Barbara, California: Brooks Foundation, March, 1966. 41 pp. (ED 010 014 MF $0.65 HC $3.29) **64**

Campbell, Pearl M. P. *Programed Versus Conventional Instruction as Preparation for Laboratory Performance.* Doctoral Thesis. Ithaca, N.Y.: Cornell University, 1969. 201 pp. Microfilm No. 69–21603. **33**

Canfield, Albert A. "A Rationale for Performance Objectives." *Audiovisual Instruction.* 13: 127–129, February, 1968. **12**

Castleberry, Frances E., and Ketner, William D. "Multi-Media Individualized Instruction." *Army Logistrician,* 2: 16–17, August, 1970. **50**

Coffey, John L., *et al. Evaluating the Efficiency and Effectiveness of Self-Instructional Methods for Selected Areas of Vocational Education. Final Report.* Columbus, Ohio: Battelle Memorial Institute, February, 1968. 218 pp. (ED 019 511 MF $0.65 HC $6.58) **34**

Cohen, Arthur M. "Defining Instructional Objectives." *System Approaches to Curriculum and Instruction in Open-Door Colleges.* Occasional Report No. 9. Los Angeles: Junior College Leadership Program, University of California, January, 1967. **12, 13**

Conroy, William G., Jr., and Cohen, Louis A. *Massachusetts and New York Evaluation Service Center for Occupational Education.* Albany: Bureau of Occupational Education Research, The New York State Education Department, May, 1970. **13**

Cook, Walter E., and Clymer, Theodore. "Acceleration and Retardation." *The National Society for the Study of Education, Sixty-first Yearbook, Part I.* Chicago: University of Chicago Press, 1962.

Cooley, Willian W. "Computer Systems for Guidance." *Computer-Assisted Counseling.* Donald E. Super. New York, N.Y.: Teachers College Press, Columbia University, 1970. **43**

Cooley, William W., and Hummel, Raymond C. "Systems Approaches in Guidance." *Review of Educational Research.* 39: 251–262, April, 1969. **44**

Cronbach, Lee J. "How Can Instruction be Adapted to Individual Differences?" Edited by Robert A. Gagne. *Learning and Individual Differences.* Columbus, Ohio: Charles E. Merrill Books, 1967, pp. 23–39. **23**

Csanyi, A. P.; Glaser, R.; and Reynolds, J. H. *Programming Method and Response Mode in a Visual-Oral Task.* Technical Report 64–129. Alexandria, Virginia: George Washington University Human Resources Research Office, December, 1964. (AD 614 014) **55**

Curl, David H. *An Exploratory Study of a Self-Instructional Method for Teaching Equipment Operation.* Doctoral Thesis. Indiana University, 1961. 138 pp. Microfilm No. 61–3201. **33**

Dawson, James I. *Effects of Sequence, Redundancy and Programing on Agri-Business Concept Learning.* Doctoral Thesis. University Park: The Pennsylvania State University, 1969. 174 pp. Microfilm No. 70–13, 817. **56**

DeHann, Robert F., and Doll, Ronald C. "Individualization and Human Potential." *Individualizing Instruction.* Edited by Ronald C. Doll. Washington, D.C.: Association for Supervision and Curriculum Development, 1964. **7**

DiVesta, Francis J. "The New Look in Learning and Development." *The Researcher.* 9: 11–21, February, 1971. **23**

Dworkin, Edward P. "Beware of False Gods." *Personnel and Guidance Journal.* 49: 242–248, November, 1970. **45**

Dwyer, F. M. *Student Perceptions of the Instructional Value of Visual Illustrations.* University Park: The Pennsylvania State University, June, 1968. **29**

Ebel, Robert L. "Some Comments." *The School Review.* 75: 26, Autumn, 1967. **12**

Edling, Jack V. "Educational Objectives and Educational Media." *Review of Educational Research.* 38: 177–194, April, 1968. **48**

_____. *Individualized Instruction: A Manual for Administrators.* Corvallis, Oregon: Teaching Research Division, Oregon State System of Higher Education, n.d. 137 pp. (ED 037 096 Document not available from EDRS) **7, 21, 64**

Edwards, Ronald K. *An Experimental Study in the Teaching of Business Machines Utilizing an Audio-Visual-Tutorial Laboratory Approach with Continuous-Loop Sound Films.* Doctoral Thesis. East Lansing, Michigan: Michigan State University, 1969. 163 pp. Microfilm No. 70–15, 020. **50**

Eisner, Elliot W. "Instructional and Expressive Educational Objectives: Their Formulation and Use in Curriculum." *Instructional Objectives.* American Educational Research Association Committee on Instructional Objectives. Chicago, Illinois: Rand McNally, 1969. **11, 13, 19**

Engelbart, Douglas C., and Sorensen, Philip H. *Explorations in the Automation of Sensorimotor Skill Training.* Technical Report NAVTRADEV-

CEN 1517–1. Port Washington, New York: U.S. Naval Training Device Center, May, 1965. 75 pp. **54**

Erickson, Richard C. "Visual-Haptic Aptitude: Effect on Student-Teacher Interaction and Mechanical Drawing Achievement." *Journal of Industrial Teacher Education.* 4: 48–55, Summer, 1967. **26**

Esbensen, Thorwald. *Working with Individualized Instruction.* Palo Alto, California: Fearon Publishers, 1968. **8, 21, 64**

Evans, J. "Behavioral Objectives are No Damn Good." *Technology and Innovation in Education.* New York: Frederick A. Praeger, 1968. **12**

Farr, Helen L. K., and Hogan, Harriett A. "Spelling and CAI." *Experimentation with Computer-Assisted Instruction in Technical Education. Semi-Annual Progress Report No. R-9.* University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, December, 1967. 82 pp. (ED 029 082 MF $0.65 HC $3.29) **40**

Fedel, Joan, and Starbuck, Ethel. *Typing and Shorthand in the Small High School.* Denver, Colorado: Colorado State Department of Education, 1965. 24 pp. (ED 036 360 MF $0.65 HC $3.29) **27**

Finch, Curtis R. *Self-Instructional Methods of Teaching Diagnostic Problem Solving to Automotive Students. Vocational Education Research Report.* University Park, Pennsylvania: Department of Vocational Education, The Pennsylvania State University, June, 1969. 114 pp. (ED 030 735 MF $0.65 HC $6.58) **28, 35**

Finch, Curtis R., and Impellitteri, Joseph T. *The Development of Valid Work Performance Evaluation Measures.* Paper read at the Annual Meeting of the American Vocational Association, New Orleans, Louisiana, December, 1970. 23 pp. **13, 14**

Finn, Audrey M. M. *The Effect of Using Motivation and Participation Questions with a Linear Program About Standard Food Measuring Equipment.* Doctoral Thesis. Lafayette, Indiana: Purdue University, 1965. 147 pp. Microfilm No. 66–2258. **36**

Finn, James D. "The Emerging Technology of Education." *Instructional Process and Media Innovation.* Edited by Robert A. Weisgerber. Chicago, Illinois: Rand McNally, 1968. **5**

Flanagan, John C. *Individualizing Education.* Paper read at the CAI Conference of the New York State Education Department and BOCES #1, Tuxedo, New York, October, 1968. **62**

Flug, Eugene R. F. *An Experimental Evaluation of Selected Presentation Modes in the Self-instruction of a Manipulative Industrial Arts Learning Task.* Doctoral Thesis. Minneapolis: University of Minnesota, 1967. 176 pp. Microfilm No. 68–7312. **51**

Folley, J. D., Jr.; Bouch, A. J.; and Foley, J. P., Jr. *A Field Experimental Study of Programmed Instruction on a Manipulative Task.* AMRL Technical Documentary Report 64–90, October, 1964. (AD 608 296) **33**

Fox, Wayne L., *et al. Aptitude Level and the Acquisition of Skills and Knowledge in a Variety of Military Training Tasks.* Technical Report 69–6. Alexandria, Virginia: The George Washington University Human Resources Research Office, May, 1969. 61 pp. (ED 041 228 MF $0.65 HC $3.29) **24**

Frantz, Nevin R., Jr. "The Development of Individualized Instruction Systems." *Journal of Industrial Teacher Education.* 7: 37–42, Spring, 1970. **64**

Fry, Edward. *Teaching Machines and Programmed Instruction.* New York, N.Y.: McGraw-Hill, 1963. **31**

Gagne, Robert M. "Simulators." *Training Research and Education.* Edited by Robert Glaser. New York, N.Y.: John Wiley, 1962. **45, 46**

Gibbons, Maurice. "What is Individualized Instruction?" *Interchange.* 1: 28-52, 1970. **3, 7, 8**

Gibbs, William E.; Hunt, Donald L.; and Fahrner, William F. "A Comparative Study of Conventional and Programmed Instruction in Bookkeeping." *Journal of Educational Research.* 61: 320–323, March, 1968. **32**

Gilman, David A., and Gargula, Clara. "Remedial and Review Branching in CAI." *Experimentation with CAI in Technical Education.* Edited by Harold E. Mitzel and George L. Brandon. University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, June, 1967. **41**

Gilman, David A., and Harvilchuck, Nancy. "Effects of Reducing Verbal Content in CAI Programs." *Experimentation with CAI in Technical Education.* Edited by Harold E. Mitzel and George L. Brandon. University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, December, 1967. **41**

Gilman, David A., and Moreau, Nancy A. "Effects of Reducing Verbal Content in Computer-Assisted Instruction." *AV Communication Review.* 17: 291-298, Fall, 1969. **25**

Glaser, Robert. "Instructional Technology and the Measurement of Learning Outcomes: Some Questions." *American Psychologist.* 18: 519–521, 1963. **14, 15**

Glaser, Robert, and Cox, Richard C. "Criterion-Referenced Testing for the Measurement of Educational Outcomes." *Instructional Process and Media Innovation.* Edited by Robert A. Weisgerber. Chicago, Illinois: Rand McNally, 1968. 569 pp. (ED 032 762 Document not available from EDRS) **11, 14, 15**

Glaser, Robert. *Evaluation of Instruction and Changing Educational Models.* Los Angeles, California: Center for the Study of Evaluation, and Pittsburgh, Pennsylvania: Pittsburgh University, September, 1968. 28 pp. (ED 032 647 MF $0.65 HC $3.29)

Glaser, Robert, ed. *Teaching Machines and Programmed Learning. II, Data and Directions.* Washington, D.C.: National Education Association, 1965. 839 pp. (ED 028 638 MF $0.65 HC not available from EDRS) **31**

Grobman, Hulda. "Evaluation Activities of Curriculum Projects." *AERA Monograph Series on Curriculum Evaluation, Volume 2.* Chicago, Illinois: Rand McNally, 1968. **43**

Grubb, James W. *An Experimental Study of the Influence of a Set of Programed Materials on Vocational Values.* Doctoral Thesis. Athens, Ohio: Ohio University, 1965. 348 pp. Microfilm No. 65–3911. **35**

Hall, Keith A. *Computer-Assisted Instruction: Status in Pennsylvania.* University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, July, 1970. 16 pp.

Hall, Keith A.; Adams, Marilyn; and Tardibuono, John. "Gradient—and Full-Response Feedback in Computer-Assisted Instruction." *Experimentation with Computer-Assisted Instruction in Technical Education. Semi-Annual Program. No. R–6.* Edited by Harold E. Mitzel, *et al.* University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsyl-

vania State University, June, 1967. pp. 2-15. (ED 028 245 MF $0.65 HC $3.29) 68 pp. **39, 41**

Haney, John B., and Ullmer, Eldon J. *Educational Media and the Teacher.* Dubuque, Iowa: William C. Brown Publishers, 1970. **49**

Harrison, Don K. *Prevocational Training for the Hard-to-Employ—A Systems Approach.* Ann Arbor, Michigan: ERIC Clearinghouse on Counseling and Personnel Services, May, 1970. 10 pp. (ED 038 562 MF $0.65 HC $3.29) **64**

Haskell, Roger W. *Effect of Personality Characteristics Upon Learning via Selected Modes of Instruction-An Experimental Investigation.* Doctoral Thesis. Lafayette, Indiana: Purdue University, 1969. 172 pp. Microfilm No. 70–8899. **26**

Havens, Robert E., ed. "Technology in Guidance." A special issue of the *Personnel and Guidance Journal.* 49, No. 3, November, 1970. **44**

Henry, Sarah T. *Questions and Answers on Programed Instruction.* Lexington, Kentucky: Kentucky University, 1968. 24 pp. (ED 025 630 MF $0.65 HC $3.29) **32**

Heyel, Clarence L. *An Experimental Comparison of Self-paced and Group-paced Auto-instructional Methods of Teaching a Manipulative Skill and Related Cognitive Knowledge in Industrial Arts.* Doctoral Thesis. College Park, Maryland: University of Maryland, 1967. 222 pp. Microfilm No. 68–16, 674. **53**

Hill, Edwin K. *The Development and Testing of an Experimental Polysensory Self-instructional System Designed to Help Students Acquire Basic Electrical Occupational Competencies. Final Report No. 19.* Pullman, Washington: Washington State University, June, 1968. 75 pp. (ED 021 141 MF $0.65 HC $3.29) **49**

Hofer, Armand G. *An Experimental Comparison of Self-instructional Materials and Demonstrations in the Teaching of Manipulative Operations in Industrial Arts.* Doctoral Thesis. Columbia: University of Missouri, 1963. 465 pp. Microfilm No. 64–4808. **34, 50**

Householder, Daniel L. "Techniques and Modes of Instruction." Chapter V in *Review of Educational Research.* 38: 382–394, October, 1968. **31, 69**

Hughes, J. L., and McNamara, W. J. "A Comparative Study of Programmed and Conventional Instruction in Industry." *Journal of Applied Psychology.* 45: 225–231, August, 1961. **33**

Hull, William L., and McClay, David R. *A Comparison of Programed and Lecture-Discussion Methods of Teaching Farm Credit to High School Youth and Adults.* University Park, Pennsylvania: The Pennsylvania State University Agricultural Experiment Station, 1965. 27 pp. (ED 013 872 MF $0.65 HC $3.29) **32**

Hyman, Theodore M., and Marsh, C. Paul. *Programmed Learning in Extension Training, A Comparison of the Effectiveness of Programmed Self-Instruction and Workshop Instruction.* Raleigh, North Carolina: North Carolina Agricultural Experiment Station, 1964. 23 pp. (ED 017 654 MF $0.65 HC $3.29) **32**

Ikenberry, Stanley O. *Instructional Systems in Higher Education—Specifications for Individualization.* University Park, Pennsylvania: Center for the Study of Higher Education, The Pennsylvania State University, January, 1970. 14 pp. **60**

Jackson, Rex. *Developing Criterion-Referenced Tests.* Princeton, New Jersey: ERIC Clearinghouse on Tests, Measurement, and Evaluation, June, 1970. 18 pp. (ED 041 052 MF $0.65 HC $3.29) **14**

Jacobs, Paul I. "Programs and Evaluation." *Automated Education Handbook.* Edited by Edith H. Goodman. Detroit, Michigan: Automated Education Center, 1965. pp. II A 51 - II A 65.

Jacobs, Paul I.; Maier, Milton H.; and Stolurow, Lawrence M. *A Guide to Evaluating Self-Instructional Programs.* New York: Holt, Rinehart, and Winston, 1966. **21**

Janeczko, Robert J. "Behavioral Objectives or Objections." *Journal of Industrial Teacher Education.* 7: 47–50, Summer, 1970. **12**

Johnson, Donald W., and Borman, Karl G. "Relative Effectiveness of Various Modes of Stimulus Presentation through CAI." *Experimentation with CAI in Technical Education.* Edited by Harold E. Mitzel and George L. Brandon. University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, June, 1967. **41**

Johnson, Kirk A. *The Advantages of a More Individualized Learning System.* Memphis, Tennessee: Navy Training Research Laboratory, 1967. 8 pp. **62**

Kelley, Charles. "What is Adaptive Training?" *Human Factors.* 11: 547–556, 1969. **57**

Kelly, William H. *The Development and Evaluation of an Educational Game to Teach Specific Aspects of Farm Management Decision Making to High School Vocational Agriculture Students.* Doctoral Thesis. Ithaca: Cornell University, 1969. 142 pp. Microfilm No. 70–3766. **47**

Klaus, David J. *The Investigation of Step Size and Error Rate in Programmed Instruction.* Technical Report NAVTRADEVCEN 1208–1. U.S. Naval Training Devices Center, July, 1964. **37**

Koontz, Jesse L. *Multi-Media Course Development.* Annapolis: Educational and Management Systems Center, U.S. Naval Academy, December, 1969. **50**

_____. (a). *CAI at the Naval Academy.* Annapolis: Educational and Management Systems Center, U.S. Naval Academy, February, 1970. 21 pp. **39, 40, 61, 62, 63**

_____. (b). *CMI at the Naval Academy.* Annapolis: Educational and Management Systems Center, U.S. Naval Academy, November, 1970. 9 pp.

_____. (c) *An Engineering Approach to Instructional System Development.* Annapolis: Educational and Management Systems Center, U.S. Naval Academy, December, 1970. 11 pp. **12, 14, 65**

Koosis, Don. "Koosis on Individualized Instruction." *Training in Business and Industry.* 7: 27–29, October, 1970. **11**

Kopstein, F. F., and Cave, R. T. *Preliminary Cost Comparisons of Technical Training by Conventional and Programmed Learning Methods.* MRL Technical Documentary Report 62–79, July, 1962. (AD 298 766) **34**

Kopstein, Felix F., and Seidel, Robert J. "Comment on Schurdak's Article." *American Educational Research Journal.* 4: 413–416, November, 1967. **40**

Kress, Gerard C., Jr., and Gropper, George L. *A Comparison of Two Strategies for Individualizing Fixed-Pace Programed Instruction.* A paper read at the annual American Psychological Association meeting, September, 1965. **54**

82

Landecker, Louis. *The Effect of Delayed-Response Learning Guides and Immediate-Response Teaching Tests on Achievement in Mechanics.* Doctoral Thesis. New York: New York University, 1969. 200 pp. Microfilm No. 69–21, 192. **56**

Lanham, Frank W., *et al. A Pilot Project in Programmed Learning to Extend the Purposes and Increase Factors of Motivation.* Ann Arbor, Michigan: University of Michigan, October, 1963. 90 pp. (ED 016 039 MF $0.65 HC $3.29) **37**

Lattes-Casseres, Virginia. *Teaching Home Management Through Simulation and Other Methods: An Experimental Study.* Doctoral Thesis. East Lansing: Michigan State University, 1968. 237 pp. Microfilm No. 69–5903. **46**

Lease, Alfred A. *An Experimental Comparison of Linear Program and Standard Textbook in Learning Basic Electronics.* Doctoral Thesis. Minneapolis: University of Minnesota, 1964. 235 pp. Microfilm No. 64–10, 834. **36**

Lehmann, Henry. "The Systems Approach to Education." *Audiovisual Instruction.* 13: 144–148, February, 1968. **59, 60**

Lindvall, C. M., and Cox, Richard C. "The Role of Evaluation in Programs for Individualized Instruction." *The National Society for the Study of Education, Sixty-Eighth Yearbook, Part II.* Chicago: University of Chicago Press, 1969. pp. 156–188. **4, 19, 22**

Loughary, John W. "Instructional Systems—Magic or Method." *Educational Leadership.* 25: 730–734, May, 1968. **64**

Lundy, Lyndall L. *Programed Booklets Compared with Sound Filmstrips in Teaching Automotive Electricity.* Doctoral Thesis. College Station, Texas: Texas A and M University, 1968. 150 pp. Microfilm No. 69–5135. **35**

MacDonald, J. B., and Leeper, R. R., eds. *Theories of Instruction.* Washington, D.C.: Association for Supervision and Curriculum Development, 1965. **6, 53**

MacNeil, Sister Catherine. *A Comparative Study of Two Instructional Methods Employed in Teaching Nutrition: Lecture-Discussion and Self-Directed Study.* Doctoral Thesis. Minneapolis: University of Minnesota, 1967. 255 pp. Microfilm No. 68–7353. **27**

Mager, Robert B. *Preparing Objectives for Programmed Instruction.* Palo Alto: Fearon Publishers, 1962. **5, 11**

_____. *Designing Vocational Instruction.* Palo Alto: Fearon Publishers, 1967. **14**

Manchak, Paul J. *An Experimental Comparison of Two Methods of Teaching a Perceptual Motor Task in Industrial Education.* Doctoral Thesis. University of Maryland, 1965. 190 pp. Microfilm No. 66–3065. **33**

Matheny, W. G. "The Effective Time Constant: A New Technique for Adaptive Training." *Human Factors.* 11: 557–569, 1969. **57**

Mayo, G. Douglas. *Programmed Instruction in Technical Training.* San Diego, California: Naval Personnel Research Activity, June, 1969. 34 pp. (MP 000 844 MF $0.65 HC $3.29) **31**

McCarley, Walter W. *An Experimental Study to Evaluate the Effectiveness of an Individualized Instructional Method and the Lecture-Discussion Method for Teaching Vocational Agriculture Classes.* Doctoral Thesis. East Lansing: Michigan State University, 1969. 177 pp. Microfilm No. 70–9599. **50**

McClelland, William A. "Simulation, Can it Benefit Vocational Education?" *American Vocational Journal*. 45: 23–25, September, 1970. **46, 48**

McCowan, Richard J., and Mongerson, M. Duane. *A Simulated Instructional Model for Educating Mentally Retarded Students for Employment in the Hotel-Motel Industry*. Buffalo, N.Y.: Buffalo College, State University of New York, December, 1969. 37 pp. (ED 038 532 MF $0.65 HC $3.29) **46, 47**

McFann, Howard H. *Individualization of Army Training*. Professional Paper 6–69. Alexandria, Virginia: The George Washington University Human Resources Research Office, February, 1969. 44 pp. (AD 685 498) **60**

McNair, Douglas D., and West, Alfred P., Jr. *Development and Testing of a High School Business Game. Final Report*. August, 1970. 71 pp. (ED 040 606 MF $0.65 HC $3.29) **47**

Meckley, Richard F. "Simulation in Leadership Training." *American Vocational Journal*. 45: 23–25, September, 1970. **47**

Melaragno, Ralph J. *A Study of Two Methods for Adapting Self-Instructional Materials to Individual Differences. Final Report*. Santa Monica, California: System Development Corporation, June, 1966. 53 pp. (AD 637 656) **24**

Melching, William H. *Measures of Ability and Programmed Instruction Performance*. Technical Report 65–12. Alexandria, Virginia: The George Washington University Human Resources Research Office, December, 1965. (AD 629 443) **26**

Melching, William H., and Nelson, Frank B. *The Influence of Practice Frames and Verbal Ability on Programed Instruction Performance*. Technical Report 66–1. Alexandria, Virginia: The George Washington University Human Resources Research Office, January, 1966. (AD 628 444) **26**

Miller, Carroll H. *Foundations of Guidance*. New York, N.Y.: Harper and Brothers, 1961. **43**

Miller, Mark, and Rosenquist, Barbara. *The Effects of Programed Instruction on Attitude and Achievement*. Champaign, Illinois: University of Illinois, March, 1965. 53 pp. (ED 010 787 MF $0.65 HC $3.29). **28**

Millman, Jason. "Reporting Student Progress: A Case for A Criterion-referenced Marking System." *Phi Delta Kappan*. 52: 226-230, December, 1970. **14, 15**

Mirabella, Angelo, and Lamb, Jerry C. *Computer-Based Adaptive Training Applied to Symbolic Displays*. Technical Report NAVTRADEVCEN 1594–1. Port Washington, N.Y.: U.S. Naval Training Device Center, March, 1966. 61 pp. (ED 018 679 Document not available from EDRS) **56**

Mitzel, Harold E., and Brandon, George L. *Experimentation with Computer-Assisted Instruction in Technical Education*. University Park: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, December, 1965. **39**

Mortensen, Donald G., and Schmuller, Allen M. *Guidance in Today's Schools (2nd edition)*. New York: John Wiley and Sons, 1966. **43**

Moxley, Roy A. "A Source of Disorder in the Schools and a Way to Reduce it: Two Kinds of Tests." *Educational Technology Review Series: Individualizing Instruction*. Englewood Cliffs, New Jersey: Educational Technology Publications, n.d. **15**

Nash, Paul; Kazamias, Andreas M.; and Perkinson, Henry J. *The Educated Man: Studies in the History of Educational Thought.* New York: John Wiley and Sons, 1965. **3**

National School Public Relations Association. *Computers: New Era for Education? Education U.S.A. Special Report.* Washington, D.C.: National School Public Relations Association, 1968. 27 pp. (ED 031 093 MF $0.65 HC Not available from EDRS) **63**

Neidt, Charles O., and Meredith, Terry F. "Changes in Attitudes of Learners When Programed Instruction is Interpolated Between Two Conventional Instruction Experiences." *Journal of Applied Psychology.* 50:130–137, 1966. **29**

Nish, Dale L. *The Development and Testing of a Polysensory Instructional System for Teaching Knowledges and Skills Associated with the Use of Expandable Polystyrene Plastics. Report No. 18.* Pullman, Washington: Washington State University, June, 1968. 66 pp. (ED 019 512 MF $0.65 HC $3.29) **49**

Norton, Robert E. *Using Programed Instruction in Occupational Education.* Ithaca, N.Y.: Cornell University, September, 1967b. 56 pp. (ED 018 660 MF $0.65 HC $3.29) **31**

_____. *Using Programed Instruction With and Without Self-Instructional Practice to Teach Psychomotor Skills. Final Report.* Doctoral Thesis. Ithaca, N.Y.: Cornell University, 1967a. Microfilm No. 67–17, 248. **36**

Nystrom, Charles O.; Morin, Robert E.; and Grant, David A. "Effects of Amount, Rate, and Stage of Automatically-Paced Training on Self-Paced Performance." *Journal of Experimental Psychology.* 49: 225–230, April, 1955. **53**

Odiorne, George S. "A Systems Approach to Training." *Training Directors Journal.* 10: 11–19, November, 1965. **59**

Office of Education. *Implementing the Vocational Education Amendments of 1968 for the Disadvantaged and Handicapped.* Washington, D.C.: U.S. Department of Health, Education and Welfare, 1970. **23**

Ogunniyi, Amotosho. *The Methodology of Educational Simulation and Design of a Simulated Instructional Model for Vocational Education.* Doctoral Thesis. East Lansing, Michigan: Michigan State University, 1969. 194 pp. Microfilm No. 69–20, 901. **47**

Pautler, Albert J. "Occupational Curriculum Development." *Journal of Industrial Teacher Education.* 7: 51–58, Summer, 1970. **12**

Perrone, Philip A., and Thrush, Richard S. "Vocational Information Processing Systems: A Survey." *Vocational Guidance Quarterly.* 17: 255–266, June, 1969. **44**

Pieper, W. J., and Folley, J. D., Jr. *Effect of Ambiguous Test Results on Troubleshooting Performance.* AMRL Technical Report 67–160, November, 1967. (AD 664 891) **25**

Pieper, William J.; Folley, John D., Jr.; and Valverde, Horace H. (a). *Learner-Centered Instruction (LCI): Volume V—Description of the Job Performance Test.* Technical Report AFHRL–TR–69–4. Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, June, 1969. 22 pp. (ED 034 942 MF $0.65 HC $3.29) **61**

_____. (b). *Learner-Centered Instruction (LCI): Volume VI—Course Methodology and Administration.* Technical Report AFHRL–TR–69–15.

Valencia, Virginia: Applied Science Associates, Inc., June, 1969. 50 pp. (ED 039 942 MF $0.65 HC $3.29) **61**

Pieper, William J.; Swezey, Robert W.; and Valverde, Horace H. *Learner-Centered Instruction (LCI): Volume VII—Evaluation of the LCI Approach.* Technical Report AFHRL–TR–70–1. Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, February, 1970. **61**

Popham, W. James. "Objectives and Instruction." *Instructional Objectives.* American Educational Research Association Committee on Instructional Objectives. Chicago, Illinois: Rand McNally, 1969. **11, 12, 14**

Popham, W. James, and Husek, T. R. "Implications of Criterion-Referenced Measurement." *Journal of Educational Measurement.* 6: 1–9, Spring, 1969. **14, 15**

Reid, Christopher; MacLennan, Donald W.; and Greenhill, Leslie. *Research in Instructional Television and Film.* Washington, D.C.: U.S. Government Printing Office, 1967. (ED 015 673 Document not available from EDRS) **48, 68**

Research for Better Schools. *A Progress Report: IPI.* Philadelphia, Pennsylvania: Research for Better Schools, September, 1969. **63**

Reynolds, J. H.; Glaser, R.; and Abma, J. S. *Learning Set Information in Programmed Instruction.* AMRL Technical Report 64–114, November, 1964. (AD 609 802) **37**

Rhode, William E., *et al. Analysis and Approach to the Development of an Advanced Multimedia Instructional System.* Technical Report AFHRL–TR–69–30, Volume I. Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, May, 1970. **49**

Roberson, Roy P. *An Experimental Comparison of Two Methods of Teaching Related Information in Distributive Education at the High School Level.* Doctoral Thesis. Columbia, Missouri: University of Missouri, 1967. 318 pp. Microfilm No. 68–3646. **50**

Rosenshine, Barak. "Review of Educational Research." 40: 279-300, April, 1970.

Rosner, Jerome. *The Design of an Individualized Perceptual Skills Curriculum. Working Paper 53.* Pittsburgh, Pennsylvania: Center for the Study of Learning, University of Pittsburgh, December, 1969. 32 pp. **16**

Rozran, Gilbert B. *A Study of the Effectiveness of a Military-Type Computer-Based Instructional System When Used in Civilian High School Courses in Electronics and Auto Mechanics. Final Report.* King of Prussia, Pennsylvania: Systems Operation Support, Inc., April, 1968. 87 pp. (ED 023 887 MF $0.65 HC $3.29) **47**

Scanlon, James A., and Tom, Frederick K. T. *The Relative Effectiveness of Supplementing Programed Instruction with Blocked Versus Spaced Review.* Ithaca, N. Y.: Cornell University, May, 1967. 45 pp. (ED 013 538 MF $0.65 HC $3.29) **55**

Schneeberger, Kenneth C. *Gaming as an Instrument of Farm Management Education—A Development and Evaluation.* Doctoral Thesis. Stillwater, Oklahoma: Oklahoma State University, 1968. 214 pp. Microfilm No. 69–14327. **46**

Schramm, Wilber. *The Research on Programed Instruction.* OE–34034, Bulletin No. 35, Washington, D.C.: U.S. Department of Health, Education and Welfare, 1964. 123 pp. (ED 003 800 MF $0.65 HC $6.58) **31**

Schurdak, John J. "An Approach to the Use of Computers in the Instructional Process and an Evaluation." *American Educational Research Journal.* 4: 59–73, January, 1967. **39, 40**

Schure, Alexander. "Educational Escalation through Systems Analysis." *Audiovisual Instruction.* 10: 371–377, May, 1965. **63**

Schwartz, H. A., and Haskell, R. J., Jr. "A Study of Computer-Assisted Instruction in Industrial Training." *Journal of Applied Psychology.* 40: 360–363, 1966. **40**

Seal, Michael R. *An Experiment to Compare Student Achievement in Beginning Welding when Taught by Lecture-Demonstration versus Modified Programed Instruction.* Doctoral Thesis. College Station, Texas: Texas A and M University, 1969. 133 pp. Microfilm No. 70–9717. **33**

Seidel, Robert J. *Project IMPACT: Computer Administered Instruction Concepts and Initial Development.* Technical Report 69–3. Alexandria, Virginia: George Washington University Human Resources Research Office, March, 1968. 85 pp. **39, 40, 55, 56**

Seidel, Robert J., and Hunter, Harold G. *The Application of Theoretical Factors in Teaching Problem Solving by Programed Instruction.* Technical Report 68–4. Alexandria, Virginia: George Washington University Human Resources Research Office, April, 1968.

Sergeant, Harold A. *Development and Testing of an Experimental Polysensory Instructional System for Teaching Electric Arc Welding Processes. Report No. 24. Final Report.* Pullman: Washington State University, August, 1968. 73 pp. (ED 022 957 MF $0.65 HC $3.29) **50**

Shemick, John M. "Teaching a Skill by Machine." *Industrial Arts and Vocational Education.* 54: 30–31, October, 1965. **51**

Shull, Howard I. *Programed Instruction: A Comparison of Learning and Retention of Information Learned Through the Use of Small Step (Linear) Programed Instruction and Large Step (Branching) Programed Instruction.* Doctoral Thesis. College Park: University of Maryland, 1969. 288 pp. Microfilm No. 70–10, 300. **36**

Siegel, Lawrence, and Siegel, D. "The Instructional Gestalt." *Instruction: Some Contemporary Viewpoints.* Edited by Lawrence Siegel. San Francisco, California: Chandler Publishing Company, 1967. **6**

Silberman, Harry, *et al. Development and Evaluation of Self-Instructional Materials for Underachieving and Overachieving Students.* Santa Monica, California: System Development Corporation, July, 1962. 121 pp. (ED 003 177 MF $0.65 HC $6.58) **24**

Simich, Jack. *Comparative Effectiveness of Self-Instructional Methods of Learning Including Programed Instruction and the Correspondence-Course Technique in Classroom Situations.* Doctoral Thesis. University of Maryland, 1965. 228 pp. Microfilm No. 66–3077. **25, 33**

Smith, Karl U., and Smith, Margaret F. *Cybernetic Principles of Learning and Educational Design.* New York, N.Y.: Holt, Rinehart and Winston, 1966. 529 pp. (ED 032 750 Document not available from EDRS) **11, 45, 46, 59**

Smith, Robert G., Jr. *The Design of Instructional Systems.* Technical Report 66–18. Alexandria, Virginia: The George Washington University Human Resources Research Office, November, 1966. (ED 014 135 Document not available from EDRS)

Sprenger, William D. *The Effects of Block Size and Mnemonic Aids Upon Paired-Associate Learning of Shorthand Symbols.* Doctoral Thesis. University Park, Pennsylvania: The Pennsylvania State University, 1970. **65**

Stephenson, Donald J. "Programed Text Versus Programed Lecture in the Teaching of Lumber Measurement Concepts." *Journal of Industrial Teacher Education.* 6: 65–68, Winter, 1969. **36**

Sticht, Thomas G. *Learning by Listening in Relation to Aptitude, Reading and Rate Controlled Speech.* Technical Report 69–23. Alexandria, Virginia: Human Resources Research Organization, December, 1969. 50 pp. (ED 037 666 MF $0.65 HC $3.29)

Stickell, David W. *A Critical Review of the Methodology and Results of Research Comparing Televised and Face-to-Face Instruction.* Doctoral Thesis. University Park: The Pennsylvania State University, 1963. **19, 51**

Stolurow, Lawrence M. *Computer-Based Instruction.* Technical Report No. 9. Urbana: Training Research Laboratory, University of Illinois, 1965. **11**

_____. *Teaching by Machine.* Washington: U.S. Government Printing Office, 1961. 173 pp. **31**

Straubel, James. "Accountability in Vocational-Technical Education." *Educational Technology.* January, 1971. 43–45 pp. **11, 69**

Sullivan, Howard J. "Objectives, Evaluation, and Improved Learner Achievement." *Instructional Objectives.* American Educational Research Association Committee on Instructional Objectives. Chicago, Illinois: Rand McNally, 1969. **16, 19, 22, 68**

Super, Donald E., *et al. Computer-Assisted Counseling.* New York, N.Y.: The Teachers College Press, Columbia University, 1970. 133 pp. **44**

Swanson, Edwin A., ed. *New Media in Teaching the Business Subjects.* National Business Education Yearbook, No. 3. Washington, D.C.: National Business Education Association, 1965. 210 pp. (ED 026 512 MF $0.65 HC Document not available from EDRS) **48**

Swets, John A. *Learning to Identify Nonverbal Sounds: An Application of a Computer as a Teaching Machine.* Technical Report NAVTRADEVCEN 789–1. Port Washington, N.Y.: U.S. Naval Training Device Center, April, 1962. 55 pp. **42**

Swets, John A., *et al. Further Experiments on Computer-Aided Learning of Sound Identification.* Technical Report NAVTRADEVCEN 789–2. Port Washington, N.Y.: U.S. Naval Training Device Center, April, 1964. **42**

Tallmadge, G. Kasten, and Shearer, James W. *Study of Training Equipment and Individual Differences.* Technical Report NAVTRADEVCEN 66–C–0043–1. U.S. Naval Training Device Center, March, 1967. **27**

_____. *Study of Training Equipment and Individual Differences: The Effects of Subject Matter Variables (Supplementary Report).* Technical Report NAVTRADEVCEN 67–C–0114–2. Port Washington, N.Y.: U.S. Naval Training Device Center, August, 1968. **23**

Taylor, John E., and Fox, Wayne L. *Differential Approaches to Training.* Professional Paper 47–67. Alexandria, Virginia: The George Washington University Human Resources Research Office, November, 1967. (AD 665 056) **23**

Taylor, Robert E., and Christensen, Virgil E. "Instructional Media in Vocational Education." *American Vocational Journal.* 42: 17–19, 46, 48–49, January, 1967. **69**

This, Leslie E. "What is Simulation?" *American Vocational Journal.* 45: 20–22, September, 1970. **45**

Travers, Robert M. W. "A Study of the Relationship of Psychological Research to Educational Practice." *Training Research and Education.* Edited by Robert Glaser. New York, N.Y.: John Wiley, 1962. **17, 19, 68**

Trimpe, Adrian, *et al. The Value of Programmed Instruction as a Tool for the Enhancement of High School Cooperative Distributive Education Students' Career Objectives.* Kalamazoo, Michigan: Western Michigan University, 1966. 108 pp. **35**

Tyler, Leona E. *The Psychology of Human Differences.* New York, N.Y.: Appleton-Century-Crofts, 1965. **23**

Ugelow, A. *Motivation and the Automation of Training: A Literature Review.* MRL Technical Documentary Report 62-15, March, 1962. (AD 277 287) **28**

Ullery, William J., and Micastro, Joseph S. *Development and Evaluation of an Experimental Curriculum for the New Quincy (Massachusetts) Vocational-Technical School. Final Report.* Pittsburgh, Pennsylvania: The American Institutes for Research, September, 1970. 166 pp. (For ED number see June *Research in Education*) **63**

Usitalo, Richard. *Systematic and Sequential Evaluation for Individualizing Instruction. A Report of a Workshop.* Olympia, Washington: Olympia School District, June, 1968. 130 pp. (ED 026 693 MF $0.65 HC $6.58)

Valverde, Horace H. *Learner-Centered Instruction (LCI): Volume I–A Systems Approach to Electronics Maintenance Training.* Technical Report AFHRL–TR–67–208. Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, July, 1969. (AD 846 721) **61**

Valverde, Horace H., and Morgan, R. L. *Influence on Student Achievement of Redundancy in Self-instructional Materials.* Technical Report AMRL–TR–68–75. Wright-Patterson Air Force Base, Ohio: Air Force Systems Command, September, 1969. (AD 686 737) **55**

Vriend, John, ed. "Counseling Technology." Special Issue of *Educational Technology,* Volume 9, March, 1969. **44**

Warner, Marion B. "Individualizing Instruction for the Disadvantaged." *Balance Sheet.* 51: 340–346, April, 1970. **8**

Warren, Charles D. "How to Staff for Quality PI." *Training in Business and Industry.* 8: 30–39, February, 1971. **11, 32**

Weinstein, Judith, ed. *Computer-Based Vocational Guidance Systems.* Washington, D.C.: U.S. Government Printing Office, 1969. (SOD NO. FS 5.255:250553) **43**

Weisz, Alexander Z., and McElroy, Linda S. *Response and Feedback Techniques for Automated Training of Visual Identification Skills.* Technical Report NAVTRADEVCEN 789–3. Port Washington, N.Y.: U.S. Naval Training Device Center, July, 1964. 27 pp. **55**

West, Leonard J. *Effects of Interval Pacing on the Acquisition of Typewriting Skill. Final Report.* New York, N.Y.: Division of Teacher Education, The City University of New York, January, 1968. 42 pp. (ED 019 510 MF $0.65 HC $3.29) **53**

Whitted, J. H., Jr.; Weaver, E. E.; and Foley, J. P. *Development and Experimental Evaluation on an Automated Multi-Media Course on Transistors.* Technical Report 66–142. Alexandria, Virginia: The George Washington University Human Resources Research Office, September, 1966. 114 pp. (AD 646 671) **49**

Wilhelms, Fred T. "The Curriculum and Individual Differences." *The National Society for the Study of Education Sixty-First Yearbook, Part I.* Chicago, Illinois: The University of Chicago Press, 1962. **8**

Wilds, Elmer H., and Lottich, Kenneth U. *Foundations of Modern Education.* New York, N.Y.: Holt, Rinehart and Winston, 1961. **3**

Wills, V. L. "Emphasizing Speed of Performance in Industrial Education." *Phi Delta Kappan.* 46: 404, 1965. **29**

Wodtke, Kenneth H. "Scrambled Versus Ordered Course Sequencing in Computer-Assisted Instruction." *Experimentation with CAI in Technical Education.* Edited by Harold E. Mitzel and George L. Brandon. University Park, Pennsylvania: Computer-Assisted Instruction Laboratory, The Pennsylvania State University, December, 1965. **41**

Wodtke, K. H.; Mitzel, H. E.; and Brown, B. R. "Some Preliminary Results on the Reactions of Students to Computer Assisted Instruction." *Proceedings of the 73rd Annual Convention of the American Psychological Association,* 1965. **25, 28**

Yeager, John L., and Kissel, Mary Ann. *An Investigation of the Relationship Between Selected Student Entering Characteristics and Time Required to Achieve Unit Mastery.* Pittsburgh, Pennsylvania: University of Pittsburgh Learning Research and Development Center, March, 1969. 22 pp. (ED 031 938 MF $0.65 HC $3.29) **24**

Zinn, Karl L. "Computer Technology for Teaching and Research on Instruction." *Review of Educational Research.* 37: 618–634, December, 1967. **39**

☆ U.S. GOVERNMENT PRINTING OFFICE: 1971 O—428-098

90